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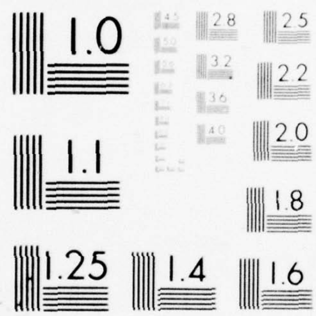

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DEFENSE SYSTEMS MANAGEMENT COLLEGE

PROGRAM MANAGEMENT COURSE

INDIVIDUAL STUDY PROGRAM

GENERAL PURPOSE COMPUTER ACQUISITION

STUDY PROJECT REPORT
PMC 76-2

Francis C. Marr
Major USA

FORT BELVOIR, VIRGINIA 22060

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DEFENSE SYSTEMS MANAGEMENT COLLEGE

STUDY TITLE: GENERAL PURPOSE COMPUTER ACQUISITION

STUDY PROJECT GOALS:

Computer usage is pervasive in civilian and government sectors. The steps which are essential to the acquisition of a computer system must be known. The goal is to provide an overview of the computer acquisition process with a discussion of the methods available to a manager in the evaluation and selection of a computer system or parts thereof.

A STUDY REPORT ABSTRACT:

The paper is divided into four major chapters, each of which takes the reader through a series of steps which are essential to the task of evaluating and selecting a computer system. Report concentrates on general purpose commercially available (non-embedded) computers. The inquiry was conducted by means of library research. The emphasis on topic selection is that of the author and is by no means either all-inclusive or exhaustive. The attempt was to review current literature pertaining to ADP acquisition process. Computers are pervasive. Project managers (PM) cannot ignore them. Typical managers prefer to delegate the subject of computers to specialist groups for detailed actions. A manager must be aware of such subjects as benchmarking, simulation, cost-value/scores-weights approach, etc., as they apply to computer evaluation/selection. This paper discusses these aspects and many more. In essence, it serves as an overview of methods in the above subject area, which a PM can use to pick and choose from as his particular rules, regulations, and circumstances permit.

ADPE COMPUTERS

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Francis C. Marr, Major, USA	PMC 76-2	November 1976

GENERAL PURPOSE COMPUTER ACQUISITION

Study Project Report

Individual Study Program

Defense Systems Management College

Program Management Course

Class 76-2

by

Francis C. Marr
Maj USA

November 1976

Study Project Advisor
LCDR Susan Anderson, USN

EXECUTIVE SUMMARY

This study provides an overview of the Automatic Data Processing (ADP) acquisition process as it relates to general-purpose (non-embedded) computer systems. It starts with a broad overview and proceeds through the general selection process with a detailed discussion of techniques which are available to a program manager (PM).

Computers are utilized in all walks of life in both government and industry. It would be a rare system which did not involve even a tangential relationship to a computer or its related equipment. A manager must be aware of the overall ADP selection and evaluation process. A PM is totally responsible for the management of his project. While experts are available to assist him in many areas he must not decide to be unfamiliar with the basic principles of any area.

This paper covers the analysis and specification of the user's system and the tools to aid in the investigation such as simulation, modeling, monitors, etc., and some commercially available software packages. Validation of the proposed computer system is the most crucial phase in the entire selection process. Several excellent methods of selection are provided in the form of the weighted scores approach and the cost-value technique. The latter method, in particular, is very valuable. This procedure recognizes the necessity for evaluating the non-mandatory requirements of a system and their costs. The mandatory requirements are validated instead of being evaluated.

It appears that the major emphasis which a manager must place in the overall process is on a modification in the initial anslysis time. In order to lessen the subjectivism which is already a part of any evaluation and to lessen the criticism of "representativeness," considerably more time and effort must be expended at the "front end" of any systems development. Many commercially available simulators must be used in order to evaluate a users present or proposed system. Benchmarks should also be utilized even though they are not always satisfactory.

In essence, the PM is provided with an overview of the evaluation and selection process. He can be brought "up-to-speed" on the subject area by using this paper. Then, depending upon the particular situation, he can pick and choose the various methods as the circumstances and rules allow.

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CHAPTER I

INTRODUCTION

1.1 General

This paper is divided into four major chapters, each of which will take the reader through a series of steps which are essential to the task of evaluating and selecting a computer system. The emphasis of topic selection is that of the author and is by no means either all-inclusive or exhaustive.

The research question is as follows:

> What methods are available to a manager in the evaluation and selection of a computer system or parts thereof?

1.2 Purpose and Scope of Research

The purpose of this research is twofold. The first is to satisfy the partial requirements for the Program Managers Course. The second purpose is my modest attempt to learn more about the evaluation and selection of a computer system. This paper is directed towards the general purpose commercially available (non-embedded) computer systems. If through this paper a project manager can more accurately determine a procedure which is useful when procurement of ADP is required for successful project completion, then this research will serve some useful purpose.

The scope of this research is limited to a general description of computer acquisitions with special emphasis on benchmarking, simulation, partial testing--in short, the workload description and validation processes. No particular computer user group is addressed. If a vendor or his products are mentioned, it is done so only in passing and then only to stress a point for discussion.

1.3 Chapter Summaries

Chapter II provides an overview of the selection process. Included therein are such factors as the basic considerations in systems procurement, sole source versus competitive bid procedures, staffing views, plus a few other comments.

Chapter III deals with the analysis and specification of the user's present system and the tools to aid in that investigation such as simulation, modeling, monitors, and some commercially available software packages. It also covers economic analysis and systems life evaluation costing. The section dealing with the validation of the proposed system is the most crucial phase in the entire selection process. Simulation is investigated, as well as the methods of central processing unit (CPU) timing, and software evaluation. Means for benchmarking are described. The last section in this chapter addresses the selection techniques through which the best overall system may be chosen. The weighted scores approach and the cost-value techniques are discussed.

Chapter IV describes the progress which has been made in the evaluation and selection process.

Chapter V contains the summary. The thesis question is addressed and the conclusions of this study paper are presented.

Two clarifying comments are needed. First, it is hoped that the research will provide a broad introduction to the computer evaluation and selection process. The outline of the chapters is intended to portray the fact that the total scope of the acquisition process must be known by a manager. In this paper the words "organization," "agency," and "corporation" have identical meaning and intent. Further, the term "system" has many meanings and connotations. In this context the word "system" refers to the data processing type meaning.

CHAPTER II

OVERVIEW

2.1 Introduction

The primary intent of Section 2.2 is to provide a broad introduction to ADP systems acquisition with emphasis on the DOD policy pertaining to this subject. Subsequent sections in this chapter provide more overview type details which must be considered by the PM in a computer acquisition. Section 2.3 covers primarily the past and present analysis aspects of computer systems design. In addition, various past and present methodolgies for testing the newly designed system are presented--the more current of which will be discussed in Chapter 3. The next section reviews basic considerations with respect to sole source versus competitive acquisition processes. A knowledge of the basic difference between these two concepts is a must for the PM, otherwise he may be tempted to jump at the first offeror who is possibly backed by a big name company. As the section points out competition is the better route. Next the PM needs to consider who is going to perform all of the evaluating and selecting tasks. Section 2.5 covers these aspects in some detail in order to provide a better understanding thereof. Lastly, Section 2.6 provides a brief discussion of probably the most key event in the entire process. The user must recognize that there are both good and bad suppliers. The basic step to eliminating much future trouble is an adequately defined Request for Proposal (RFP). While this subject will be discussed later, it is essential to bring out certain salient overview facts.

2.2 Basic Considerations in Systems Procurement

A comparison among various computing systems available today is becoming more difficult since many systems differ in size, configuration, and basic design. Before the evaluation and selection process can begin, however, some basic considerations must be addressed.

Though rarely a controlling factor, the cost of the potential acquisition is still a major factor and little has to be said to stress its importance. Without this constraint little effort would need to be expended in modeling, simulation, and benchmarking.

Time is an important factor in most system procurements. Besides the fact that the user would like to have his new equipment as soon as possible, it is important that each phase of the acquisition be alloted enough time to permit full completion of its associated tasks. The time allotted to each phase in an evaluation and selection process is system dependent. The more complex and costlier system must be alloted more resources, both in terms of dollars and time. Expenses for smaller procurements are, by necessity, curtailed if the selection process is to remain economical.

The following table, taken from the General Services Administration ADP Procurement Guidelines, indicates the various time spans for the elements of the competitive procurement cycle. This was determined from a recent interagency study.

Request for Proposal (RFP) Development	5 months
Delegation of procurement authority from GSA	20 days
Benchmark time	40 days
Technical evaluation time	14 weeks

Contract negotiations	6 weeks
Cost evaluation time	12 weeks
Selection time	6 weeks
TOTAL	45 weeks

The above times are historically typical. Consequently, the total for all elements of the procurement cycle will not necessarily equal the average time for that category of procurement. It should be noted, however, that a recent study by Mr. Robert H. Parke (PMC Class 76-1) indicated that an average processing cycle of 65 weeks existed within the Department of the Army on ADP procurement actions. (20, 19)[1] As a result one should view the procurement cycle with extreme caution and planning whenever ADP is involved in a program. In essence, one will not just order a computer today and receive it tomorrow.

The user's needs may change if the acquisition cycle is long enough. In addition, staff salaries, the number of system analysts and programmers, and similar factors can profoundly affect the cost of a computer system and the productivity it provides. (26, 202)

Alternatives to the established plan should become part of the plan and not dismissed out-of-hand. For various reasons it may be less costly to lease a new system rather than purchase the equipment outright. Similarly, the entire exercise may prove that updating the current system is cheaper. In addition, it may prove that the existing system will be

[1]This notation will be used throughout the report for sources of quotations and major references. The first number is the source listed in the bibliography. The second number is the page in the reference.

satisfactory for X more years. Since most system development is approached with a "let's dream" attitude, alternatives in costing should be considered such as determining the total cost of the new system both with and without the "bells and whistles."

Another basic factor which must be considered before proceeding with a system procurement is the impact of a new system on the organization as a whole. Literally hundreds of books and thousands of papers have been written on the effects that new influences have on employees when they are taken out of their old environment. Depending on the complexity of the system in question, retraining and reeducating must be considered. During the acquisition, some departments may be reduced in size while others grow. In essence, the total impact must be known beforehand.

Within the Department of Defense (DOD) policy and guidance for the selection and acquisition of ADPE is contained in DOD Directive 4105.55. (7, 3) Of particular importance to the project manager in the acquisition process are the following policy statements:

a. Decisions to acquire ADPE will be preceded by and predicated upon the results of well-documented studies that indicates:

1. That a valid information requirement exists. The functions or processes to be accomplished through the use of automatic processing are essential to mission requirements.

2. That automatic processing is the most cost-effective means of satisfying the requirements.

3. That the system to be employed has been designed to achieve the highest practical degree of effectiveness and operational economy.

4. That the lowest overall cost alternative for satisfying the requirements has been determined prior to selection and acquisition of ADPE resources.

b. Specifications to support the acquisition of ADPE resources will be developed independently of a specific vendor's products. Equal opportunity and consideration will be accorded to all vendors who offer products capable of meeting the specifications.

c. The method of acquisition will offer the greatest advantage to the Government under the circumstances surrounding the situation.

d. To further promote effective selection and acquisition of ADPE resources, a professionally staffed activity with primary full-time mission to develop solicitation documents, evaluate vendor responses and competitively select ADPE will be established within each military department.

In addition to the technical and management policies contained in the directive, selection and acquisition of ADPE resources will be in accordance with the policies and procedures of the Federal Property Management Regulation (FPMR) and the Armed Services Procurement Regulations (ASPR). In the event of conflict between the two government regulations, the provisions of the FPMR govern.

The directive also delegates responsibilities to the secretaries of the military services to approve the selection of ADPE resources and to issue appropriate implementing documents and procedures.

2.3 Past and Present Methodology in System Procurement

In the early days, the existence of an operational computer system was virtually an end in itself. Different systems were compared with easily observable quantitative characteristics such as memory size, number of instructions executable in a second, speed of printers, card readers, or clock rates of the equipment. As the logical design and usage of information processing equipment became more complex, it became apparent that such easily observed or measured physical parameters did not always yeild an inference as to "quality" or "goodness" which correlated well with ones intuitive feeling about the relative work or usefulness of differeny systems. (22, 2) In the 1950's, <u>in</u>dependent sub-systems were designed for <u>inter</u>dependent activities. Further, the systems of the 1950's were largely operational-level systems. They provided the information needed by first-level supervisors and their subordinates. (6, 198) From this, it is evident that the early systems were indeed easier to evaluate. Concreteness and simplicity of design as well as ease of application were the major contributing factors. As the systems grew in scope and complexity, so did the problems of evaluation and selection. The independent sub-system, such as the payroll programs, became a small part of a larger financial system.

With system complexity came evaluation complexity where systems analysis techniques lagged one generation behind those machines which were to be acquired. Only in recent years have techniques narrowed the gap between the hardware and its evaluation. The stress in performance evaluation has shifted from programming and testing of new systems to the "front end" approach which includes documentation of the present system, evaluation of system requirements, and designing the improved system. (6, 168) As the stress on analysis grew--directly affected by the systems complexity--so grew the methodology available to the analyst. The period between 1920 and 1950 saw the development of paperwork and process flowcharts. Their major shortcomings were the lack of the identification of data elements and volumes. During the 1950's, general flowcharts and block diagrams evolved based on previous attempts at accuracy. The period 1960-1970 saw the greatest progress in the analysis of computer systems. NCR's Accurately Defined System (ADS) was an improvement on the use of charts since it provided a well-organized and correlated approach to system definition and specification. (6, 173)

ADS used five interrelated forms to provide the system (application) definition. The process began with the definition of output. Next, inputs were defined--on the second form. The third form provided the definition of computations to be performed and the rules of logic governing the computation. The interrelationship of computations were also defined on this form, as were the sources of information used in the computation. The fourth form, the history definition, specified information to be retained beyond the processing cycle for subsequent use. The fifth form provided the logic definitions, in the form of a decision table.

Within ADS, information linkage was accomplished in two ways. First, each data element was assigned a specific tag or reference. Next, each time the tag was used in the system, it was linked back to the previous link in the chain. All elements of data were chained from input to output, accomplished through the use of page and line numbers. The process of chaining facilitated identification of omissions and contradictions in the system. Once the information requirements were established, the system design phase determined the appropriate hardware mix to effect the system.

Another approach, known as information algebra, based on the efforts of Mr. Robert Bosak, provided the theory for systems specification. Information algebra was an important development because it provided a theoretical basis for automatic processing of system specifications. The primary intent of information algebra is to extend the concept of stating the relationships among data to all aspects of data processing. This will require the introduction of increased capability into compilers for translating this type of relational expression into procedural terms.

While both of the foregoing were based on the assumption that the study of the organization and its needs had been completed, two new developments, ARDI (Analysis, Requirement Development, Design and Development, Implementation and Evaluation) developed by Philips, and Study Organization Plan (SOP) developed by IBM, aided the initial phase of analysis. The latter is the more significant contribution to the field because if pulled various techniques together into an integrated approach. SOP was designed to gather data with which to analyze the information needs of the entire organization. (6, 174)

Another improvement which made analysis easier was the use of the Hoskyns System. (6, 191) Using the Hoskyns approach the system is described in terms of programs and files with the programs being described in terms of records and data elements. These sets of relationships are recorded in the form of matrices. In summary, the Hoskyns system accepts system specifications and converts them to COBOL programs without manual intervention. The system was developed and implemented in three British corporations by Hoskyns Systems Research Incorporated. It was introduced in the United States in 1972 and is in use at Xerox, General Foods, and Allied Chemical.

Whereas the first and second generation analysis techniques concentrated on suboptimization within a given organization, third generation systems philosophy is concentrating on studying the organization as a whole. This new idea presented an even larger problem for the analyst until a new approach was devised. This is known as Problem Stated Language/ Problem Stated Analyzer (PSL/PSA). The concept was now different. The analyst asked <u>what</u> he wanted to inspect regardless of <u>how</u> those needs should be met. The Problem Statement Language (PSL) is designed to express desired system outputs, the data elements which comprise these outputs, and formulas to compute their values. The user specifies the parameters which determine the volume of inputs, and the outputs and the conditions (particularly those related to time) which govern the production of outputs and the acceptance of inputs. The Problem Statement Analyzer (PSA) accepts inputs in PSL and analyzes them for correct syntax, then:

a. Produces comprehensive data and function dictionaries.

b. Performs static network analysis to insure completeness of derived relationships.

c. Performs dynamic analysis to indicate time-dependent relationships of data.

d. Analyzes volume specifications.

So far only the analysis aspect of computer systems design and evaluation techniques have been discussed. The question still to be answered is: What methodology is available for testing the newly designed system?

As previously stated, the earlier systems were relatively easy to evaluate due to their similar characteristics of size, number of instructions executable in a given period of time, etc. As the configurations became more complex and multiprogramming and multiprocessing became more prominent, the evaluation techniques available had to undergo complete changes in order to meet these new innovations.

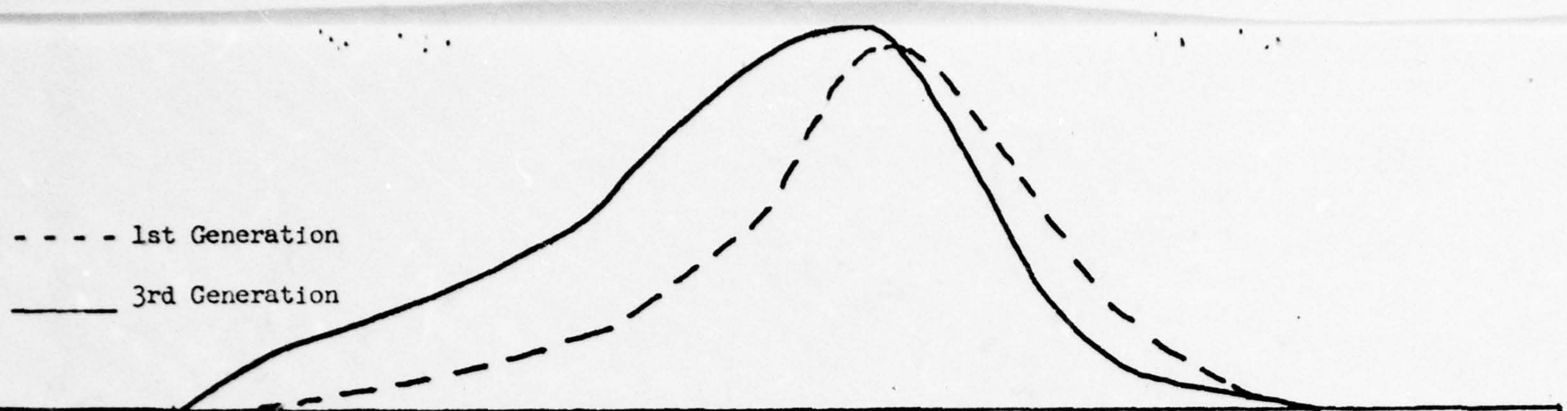
The earliest attempts at CPU evaluation were the two interdependent "instruction mixes" and "kernel" methods. In the mix method, each instruction or related group of instructions in the repertoire of a computer is assigned a weighting factor obtained by analysis or measurement of a program or programs in execution. Applying the weight to each instruction provides an average instruction time that can form a basis of comparison between two or more systems. (9, 257) The technique in the kernel method is to determine the most frequently used portions of an application and to program these portions in the various instruction sets of the cnetral processing units being compared. After each kernel had been evaluated, they were combined according to some weighting function. Although the kernel method was a better tool than the instruction mix, both methods have now been discarded in most evaluation and selection procedures. The instruction mix is no longer used since a single weight is used in evaluating the performance of systems with different instruction sets, memory configuration, etc. (9, 257) The kernel method has fallen into disuse primarily because it ignores input/output considerations and software performance factors. Moreover, it is usually difficult or impossible to relate the time for an assortment of kernels to a given user's real time data processing applications. (22, 6)

With the instruction mix and the kernel method falling into disuse, the benchmark method gained in popularity. A commonly accepted definition of the benchmark method is a program or programs which seek to represent by representative programs the total automatic data processing (ADP) workload. (5, 41) In the context of this definition, the current workload with expansion is designed and executed on several configurations. The results are then compared. Although quite popular, the method has some inherent or potential pitfalls. The definition of a "representative" workload is most probably the most prominent. The central difficulty lies with establishing the representativeness of the job or jobs being run considering that they are usually a very small sample of the actual workload planned for the system in question. (22, 7)

Other factors which are known to affect the outcome of any benchmark test are "CPU utilization," "channel utilization," "terminal response time," etc. To aid in the evaluation of these factors, simulation has become quite popular due to its flexibility, despite the high cost and time factors involved in writing and running these packages. During the 1960's, several simulation languages were developed and now operate with a high degree of proficiency.

Finally, hardware and software packages were and are still being developed to aid the performance evaluator. Both packages have limitations, but they are acceptable as tools which help in the validation and verification of programs being executed on a system. The software monitor is a program which is usually imbedded amongst the operating system and production programs of a system. As the system executes, data is collected which states something about the sequence of events, queues, timings, memory cycles, etc. The drawback to these software packages is the fact that the measuring program itself can adversely affect the system being measured. The measuring program is using the system's memory, input/output devices, etc.---exactly those components which it is to measure. To overcome this problem, hardware monitors have been developed which are connected to key points in the system. Although they do not interfere with the operation of the system, their drawback lies in the limited number of system points that can be connected to the monitor.

The cost of system development and procurement are not cheap. Many managers enter into the arena without any idea of the cost distribution involved. Figure 2-1 presents an overview of the systems development costs as they existed in the recent past. It is worthy of note that more effort is required during the initial phases of the computer project. Both the amount of cost and the distribution of resources have changed. In first generation systems, Phases I and II absorbed approximately five percent of system development cost. The expanded scope and sophistication of third generation systems has increased overall development cost, with approximately twenty percent absorbed by Phases I and II.



	SEVEN STAGES IN SYSTEM LIFE CYCLE						
	I Documenting existing system	II Evaluating system require-ments	III Designing improved system	IV Program-ming and testing new system	V Implement-ing the new system	VI Operation of the new system	VII Maintenance and modi-fication
1st Generation systems	1%	4%	20%	55%	20%	--	--
3rd Generation systems	10%	10%	25%	40%	15%	--	--

Comparative costs of 1st and 3rd generation system development.

Figure 2-1

2.4 Sole Source vs. Competitive Bids

Today most computer acquisitions are made through competitive bids, that is, more than one vendor responds to the Request for Proposal (RFP) and offers what he believes to be the best system or systems. Procurement of ADP is generally done on the basis of three general principles. It may be obtained by general performance specifications. This normally applies to an entire system. Second, the user may only have need for an equipment specification (i.e., terminal) in which case his requirements are stated in terms of a piece of equipment. Lastly, specified ADP may be requested (i.e., IBM 360) by the user. In essence, specified ADP is a make and model description. (1, 4) The federal government generally requires competitive bids on any major system. Few exemptions are granted, and only then, if it can be shown that sole source acquisition is the most cost effective. Most sole source acquisitions are justified under several circumstances. As an example, only one vendor has the specific equipment needed or the conversion effort is too great. The key ingredient in the request for specified ADPE or sole source is the rationale to support how the requested ADPE was evaluated and why it was determined to be the best or only equipment which will satisfy the requirement or need. (27, 31) Sole source has its advantage. The evaluation becomes a routine task in that the user makes a rather perfunctory check of system capability. In this respect, the evaluation and selection method costs very little. Sole source acquisition rests, of course, on the premise that the user knows the equipment's capability and his own needs well enough to be able to pick a specific manufacturer.

This type of acquisition, however, does a disservice to most users. No matter what the requirements may be, there are at least two vendors who will be able to meet them. If this is not possible, then it may be advisable to look at the overall operation and see if changes cannot be instituted which will allow greater latitude. Competitive bids allow the user to pick and choose his equipment based on need, cost, and performance. In some cases, vendors have bid systems whose configurations were far superior to those that the user had in mind. There are disadvantages to this method of procurement. Competitive bids are costlier than sole source since the existing system must first be documented; second, an RFP must be prepared; third, the validation of the proposal including system performance measurement must be made; and lastly, the actual system must be selected.

2.5 Evaluation and Selection by Permanent Staff versus Consultant Firm or Ad Hoc Committee Usage

For those organizations whose primary mission demands the support of one or more ADP facilities, the need for a permanent staff of highly trained computer professionals has grown from one of novelty to one of necessity. Technological advances have come with startling rapidity as computing machines spread over a spectrum ranging from the minicomputers to the "number crunchers." These individuals are usually up-to-date in their speciality of hardware configurations, software, simulation, etc. They are familiar with the organization's problems and they play an active and vital role in the evaluation and selection process. In those areas which are sensitive because of security or proprietary matters, a permanent staff is usually a must. Despite these advantages, a permanent staff has one real and one potential drawback--cost and tunnel vision or stagnation. A professional group is quite expensive and adds to the corporate overhead. As much as eighty-five percent of a facility's total budget has been assigned to the maintenance of programming and analysis support. Tunnel vision is, of course, only a potential problem. As the group becomes familiar with the current equipment in its day-to-day activities, the equipment itself will impose its limitations and constraints on those directly dealing with it. In the future, suggestions for solving problems will be rejected because the limitations of the current system do not allow the suggested solution. They will normally not be rejected because they are unworkable.

The use of consultants must be considered. While the consulting firm is less expensive than the maintenance of a permanent professional staff, it contains all the merits of the latter. The firm is employed only for the development through the test and evaluation phases of the system and usually ends its association with the organization after the last piece of equipment has been installed and accepted. As an example the U. S. Army's supply system in the Pacific area of operations (3S) was developed and maintained by the Computer Services Corporation (CSC). In fact, CSC provided systems personnel on-site in Vietnam to maintain the 3S system. In some instances the firm will be retained on a part-time basic--just in case problems develop after the system is installed. Again, some typical pitfalls must be identified. If the consultant has enjoyed great success with a particular application, he may recommend a repeat performance with an identical or similar system even though it may not quite meet the organization's needs. Depending on the consultant's own background, experience, and inclination, an organization acquiring new and unfamiliar equipment may be persuaded to purchase a more expensive system from a particular vendor since those products are most familiar to the consultant.

In most cases, the ad hoc committee is the least expensive path to follow in choosing an evaluation and selection team. Members of the team are normally from the organization acquiring the computer, therefore, they are usually familiar with the problems and as a result little time must be wasted in explaining the processing, needs, and policy of the organization. Mr. E. M. Timmreck suggests that this is quite satisfactory for acquiring an upgraded system. (26, 200) They will essentially add a few ADP components to the system, make the necessary comparisons, and purchase the cheapest system. This method is also equally workable if a sole source procurement is desired. The drawbacks to the ad hoc committee are obvious. The group has little expertise in computing machinery in general and no experience at all in computer evaluation. If the contarct has a high dollar value and many vendors are invited to bid, it is safe to assume that the system which is finally purchased is not the best system that could have been acquired for the money expended.

What then is the proper combination? Although no firm rules are available, Mr. Edward C. Joslin suggests all three may be used depending upon the expected system's complexity, the ad hoc committee's understanding of the computer evaluation and selection process, and the experience of the permanent staff. In the majority of cases, a combination of all three groups is used. Members of the ad hoc committee are usually appointed project managers with the consultants and the permanent staff of ADP professionals assigned supporting functions such as costing, benchmark definition, etc.

2.6 Vendor versus User Considerations in System Procurement

Although the title of this section may imply that an antagonistic relationship exists between any given vendor and user, little evidence appears to support this view. One fact, however, is obvious. The vendor wants to sell his line of equipment and he hopes to persuade the potential user to purchase it.

Assume for the moment that the RFP has been completed stating the mandatory requirements and the desirable features. The organization expects a large response, yet it receives only a few politely worded inquiries. What are the possible causes:

a. The RFP addresses few vendors who manufacture a mandatory piece of equipment.

b. To bid is too costly for a large number of vendors. This is one point that seems to have been overlooked either due to unawareness by those who write the RFP or due to limited resources which will be expended on the purchase. Bidding can be expensive. Preparing a reply to a proposal can cost anywhere from $1,000.00 to well over $400,000.00. This expense must be borne by the vendor who has no guarantee that he will be awarded the contract. For instance, at UNIVAC's Marketing Test Center usually two to five benchmarks are in process with another ten to fifteen in various stages of completion. An average benchmark takes from six to twelve weeks to complete. This process uses approximately 100 hours of actual computer time and from sixty to seventy-five total manweeks. Some calculations can quickly verify the fact that an RFP, describing any system, is an expensive proposition for any vendor.

c. The RFP is not clearly written. The RFP should be precise in its wording, leaving nothing to the fruitful imagination or to the "benefit-myself" interpretation of the vendors. Unless sole source acquisition can be justified, the request should be general enough in its requirements to allow as many vendors as possible to complete without comprimising the needs of the organization. Further, a well-written RFP steers the vendors in the right direction. They need not waste their resources in trying to guess what the buyer really wants.

CHAPTER III

THE SELECTION PROCESS

3.1 Analysis and Specifications of the Present System

As was shown in Section 2.3, more and more time and effort is expended at the "front-end," that is, during the initial phases of any computer acquisition. Depending on the author, any number of steps can be cited which should be included in this initial period. Mr. Joslin, one of the most prolific writers on this subject, suggests three basic steps which should be followed in the beginning efforts. The three steps are: (1) data gathering or investigation of the present system plus any new requirements; (2) analysis of the data gathered in the investigation; and (3) synthesis, or refitting of the parts and relationships uncovered through analysis into a better system. (13f, 63)

One important point must be discussed before this topic can be further explored. Is this acquisition the user's first or does he already have a system? Mr. Timmreck points out that drawing up specifications of need for the former will be much more difficult. (26, 205) For example, the small organization without a computer must first very carefully ask itself whether it really needs one. It is quite possible that the company's needs can be satisfied by other means rather than purchase. The fallacy of owning a system, and one that may be too large, was shown in the early part of the 1970's. Over 200 software houses and service bureaus closed their doors. Overspending on computer systems coupled with a declining need and a slowing economy were the chief reasons for these closures.

In either case, a very thorough examination of the organizational objectives should be undertaken. Since members of the team come and go, these objectives should be in writing and given to each member of the team. (13f, 63) These objectives should be specific enough so that a long-range plan--5 years or more--can be developed. A thorough examination of the organization must be made. By this I mean "who does what to whom" and what are their interrelationships. Historical data must also be gathered. Why is the present system operating in this manner? What are the policies, practices, and regulations? The analysis should focus on detailed breakdowns of the workload classes, isolate specific projects, organizations, and personnel requesting service. Statistics showing the total machine time used and the number of jobs each of the aforementioned ran in a given period must be gathered. Priorities and their assignment procedures must be analyzed. Many organizations have some dedicated jobs which must be executed at specific intervals, i.e., payroll. These, too, must be isolated and their time and number recorded. The type, duration, and priority of the backlog must be examined. The means of backlog resolution must be known. Further, the idle time of the system must be determined. Specifically, this phase should be divided into operational and system characteristics.

Operational characteristics fall into several categories. Questions concerning common operator errors which affect thruput, job scheduling, user dialogue, document problems, availability of tapes and discs, etc., are certainly germane. Users of the system should be questioned concerning turnaround adequacy. The system logs should be examined to determine the number of hours per recording period in which the machine was emulating, simulating, idle, compiling or assembling, inoperable due to hardware or software failure, or down due to preventive maintenance. Some statistics should be gathered on the number of forms which are used. Finally, resources expended in both man-hours and machine time must be examined.

The system's characteristics must also be examined. Data concerning CPU utilization per month, the peaks and valleys of the jobs in core, the number of input/output (I/O) operations, the support equipment available (such as tapes and discs), opinions from systems programmers on the limiting factors (core, disc, memory, channels, etc.) must be obtained. If possible, information on the time spent for solving production problems, aiding users, maintaining old applications, developing new programs, and altering software must be gathered.

The next step is to consider the areas of process descriptions and narrative flowcharting. Process description concerns inputs and outputs. It essentially involves interviewing those individuals who receive reports or those who generate them. Areas of investigation are the report need, format, and frequency. The purpose of the investigation is threefold: (1) determine exactly what is used; (2) what can be eliminated; and (3) what else is needed. It is here that each job or group of jobs must be thoroughly investigated. Characteristics of each input/output should show CPU usage per job in both prime time and non-prime time. The analysis must show for each job the number of tapes and discs used, the percent that compile or assemble, the language each one uses, the percent of CPU time used (for production jobs), the number of production jobs, and I/O times. As is the case in most facilities, there are always a few programs which are classified as the largest, the most executed, and the most important. It is advisable to isolate these runs and prepare separate information sheets on each. Much of the present system may be shortened, rewritten, or totally eliminated. This is particularly true for a very large system that has been in existence for a number of years. The tendency is to expand, unfortunately not always in an orderly fashion. Usually much redundant information is gathered. Depending on the accuracy of the reporting system, current evaluation criteria and reports may be used. The last portion of this subject concerns processing or in other words converting given inputs into desired outputs. In this connection one must determine the file sizes, update frequencies and number of records per file, plus a host of other variables.

Narrative flowcharting is the process of documenting the present system. It shows the current processes and subprocesses at various stages of completion. Narratives should be as specific as possible when dealing with rates, volume, standards, and peakloads since these will be used in workload determination and benchmarks. It is the purpose of the narrative to cross-reference all the I/O's which were gathered in the process description.

The second step in this overall process is the analysis of the information which has been gathered. All I/O's should now be logically arranged in sequence. The pertinent files are examined. The relationships between files must again be questioned. Some files may be dropped, modified, or carried as they are presently designed. The information gathered up to this point should now give a clear picture of the various functions which are directly related or affected by the current system. The data can be utilized for:

a. Job accounting--CPU time + tape, etc.

b. Program analysis--number of test runs and their frequency; machine time required for test runs; peripheral resources used.

c. Multiprogramming effectiveness--machine hours overlapped, number of tasks concurrently processed, CPU usage, I/O usage, idle time.

d. Operations analysis--idle time, set up time, efficiency of schedule.

e. Program profile--processing requirements, I/O dependency of jobs, CPU-I/O balance.

f. Resource utilization--resources used by load modules, load module frequency utilization, I/O dependency of load modules.

g. Hardware analysis--core size impact, CPU speed impact, I/O device impact, channel impact.

At the conclusion of this phase, the entire system as it currently exists should be known in the fullest detail. The analysis may bring some unexpected surprises in that the findings may show that a new system is not needed. Dropping of redundant information or the acquisition of more memory, a disc, or several tapes may be all that is needed. Although only a few such cases can be found in the literature many more are likely to exist. (25, 1225-1233)

The final step is that of synthesizing this information with those objectives that must be met by the new system. Five factors may be considered important in a good system design:

a. Try to minimize input and output operations.

b. Where possible, source information should be initially transferred directly into a media acceptable as input to the computer.

c. Seek multiple uses of common source data.

d. Attempt to keep the system simple, flexible, reliable, economical, and acceptable to the users.

Again, as this evolution progresses, steps must be taken to rid the system of many anachronisms which crept in over time, and were later declared law. The word here is standardization--a costly, though worthwhile, effort. Mr. Timmreck states, "Clearly, an organization's approach to standardization will significantly affect its flexibility when selecting a computer system. An organization which strongly emphasizes programming standards will normally be relatively free to switch from one manufacturer to another." (26, 204) With government support or pressure, more and more aspects of the computer industry are being standardized. The federal government's insistence on the usage of COBOL, as well as the current attempts by the Army, Navy, and the National Bureau of Standards to arrive at standard benchmarks serve as examples of standardization.

As all of the information is synthesized, various computer configurations must be studied. Flowcharts which indicate volumes, record length, I/O device type, frequency of execution, etc., should be used. At this stage, trade-offs must be made. As an example, discs may be a favored media; however, the application may be done on tape just as well. In this case the price of the devices may be the determining factor. The most satisfactory method of determining a system design is to develop from "the system" downward listing as many variations as meet the need. After this has been completed, it is possible to choose parts of each in order to arrive at the optimum system which meets all constraints. In essence, a hybrid system is developed. After the final system is designed, it should serve as a basis for comparison. It should not, however, be used as an absolute system. Each vendor will, no doubt, bid one or more systems which may be radically different from the synthesized configuration, yet meet the user's needs.

Even though it is almost trivial, a final comment must be made about the importance of determining the objectives of various potential users followed by the analysis of the users present system, and finally the synthesis of all parts into a design. Considerable effort can be avoided by systematically going through these steps. The RFP will be easier to write since everyone knows exactly what is needed. After having accomplished these details the subsequent evaluation and selection process should be more manageable.

3.2 Systems Life Evaluation Costing for ADPE

3.2.1 General

A good comparative cost analysis is essential to the ADP selection and evaluation process. To use this technique properly, it is necessary to bring together all costs over the stated systems life. In addition, the following points must be considered: systems life, present value discount methodology, residual value, and the various procurement methods available. (12)

3.2.2 Systems Life

The systems (items) life must be established by the Government based upon its requirements and it must be stipulated in the Solicitation Document. The "systems or items life" means a forecast or projection of the period of time which begins with the installation of the systems or items and ends when the need for such systems or items has terminated. Systems or items life is not synonymous with actual life of the equipment.

3.2.3 Present Value Discount Methodology

The present value discount methodology as set forth herein formalizes a single discount rate of 10% for all DOD agencies. The single rate specified--10 per cent--is approximately the long-run opportunity cost of capital in the private sector. Under this concept, the payments made over time will be adjusted to reflect the present value of those payments as of the data of contract award. Thus, "all expenses," while waiting for equipment delivery or after installation for the stated life of the system, must be adjusted to reflect present value. "All expenses" includes not only the offeror's prices (equipment, software, and support) over the systems life, but also predetermined in-house expenses for ADPE installation and operation.

The following formula is to be used in calculating present value cost:

Expected		Discount		Present
Monthly	X	Factor	=	Value
Cost		for 10%		Cost

3.2.4 Residual Value

Usually, at the end of the stated systems life, the computer system still has some value to the Government. This value may reflect the fact that the initial using activity may well keep the system longer than planned or some other Government activity may reutilize the hardware. The future lease payments saved, as well as the resale value of the equipment at the end of the stated systems life, affect residual value. The residual value varies with each activity. However, for general purpose equipment it is expected that after a five-year systems life the equipment should still be worth approximately 20-30% of the purchase price and after eight years, about 10%. The following formula can be used to determine residual value:

Purchase Price * X ______% X Present Value discount factor for last month of systems life = Residual Value

In the above formula "purchase price" is the lowest evaluated purchase price offered by a responsible and responsive offeror. Any procurement option (e.g., Purchase, Lease-to-Ownership, etc.) that results in the Government owning the system(s) will have the residual value deducted from the systems life cost for evaluation purposes.

* Including the operating software, if priced separately from the equipment purchase price, and a perpetual license has been obtained by the Government. Instead of the straight purchase price, the sum of all invoice payments to be made to the Contractor may be used as the basis for this calculation.

3.2.5 Procurement Methods

Systems life costing should be calculated for each procurement method offered. Examples of the plans currently being offered are:

a. Purchase: Outright purchase after installation and acceptance of equipment.

b. Lease:

(1) Lease with Purchase Option: Lease with option to purchase at predetermined intervals of time. The purchase price is usually reduced by subtracting rental credits as set forth in the offeror's proposal. Purchase option credits greater than 100% of monthly charges shall not be considered in evaluating offers for award.

(2) Long Term Lease: Such plans may provide multi-year leasing at determinable prices where the agency exercises a renewal option at the end of each fiscal year.

(3) Lease-to-Ownership Plan or Lease with Title Transfer Plan: A plan whereby title transfers after payment of n months of rental, but usually with no obligation, or less obligation, to continue to lease than in (4) below. Normally, title transfer does not occur in less than six years.

(4) Installment Purchase Plan: A plan whereby the Government exercises an option to purchase the equipment upon payment of n months of payment. It is frequently offered as a fixed term installment plan usually for 36 or 60 months in which the Government either is granted title immediately or title is passed at the end of the contract. Normally, an installment purchase plan cannot be consummated using annual

appropriations. Care should be taken during negotiations to ensure that the Government retains accrued credits and/or equity under any of the plans in (b) above, should the agency requirement cease or funds no longer be available.

3.3 Alternative Acquisition Analysis

It is very important that an analysis of the alternative methods of acquisition be followed with great care and precision. Frequently, the same vendor will not be low on both lease and purchase plans. Exhibits A - D on the following pages show examples of different lease and purchase plans, as computed under the present value discount methodology.

REMARKS ON EXHIBITS A TO C

1. The present value cost is determined by using a discount rate of 10% carried to six decimal places and assumes end of the year costs. The discount factor for the last month of each year was used (i.e., 12 months - .909091; 24 months - .826446; 36 months - .751315; 48 months - .683013; 60 months - .620921; 72 months - .564474) for the sample analysis. In an <u>actual</u> economic analysis, the preparer would use the applicable discount factors provided by their department.

2. Six year systems life.

3. Residual Value was determined as follows:

Purchase Price				Present Value Discount Factor for last month of systems life		Residual Value
$610,000	X	20%	X	.564474	=	$68,866

4. The Solicitation Document should clearly state how the purchase option will be evaluated for purposes of award.

EXHIBIT A

ADPE SYSTEMS LIFE COST BY FISCAL YEAR

	0	1	2	3	4	5	6	TOTAL
1. Lease basis with-option-to purchase (option exercised at the end of 18 months)								
a. Lease (including maintenance) 1st 12 months		$156,000						$156,000
b. Lease including maintenance 13th month thru 18th month			$78,000					78,000
c. Purchase Price			610,000					610,000
d. Purchase option credit of 80% of rentals paid ($234,000 x 80%)			(187,200)					(187,200)
e. Maintenance of Gov't-Owned Equipment								
2nd year (6 mos.- $14,835)			14,835					14,835
3rd year				$29,670				29,670
4th year					$29,670			29,670
5th year						$29,670		29,670
6th year							$29,670	29,670
Total a thru e		$156,000	$515,635	$29,670	$29,670	$29,670	$29,670	$790,315
Adjustment Factor	1.00	.909091	.826446	.751315	.683013	.620921	.564474	
Adjusted Total	-	$141,818	$426,144	$22,292	$20,265	$18,423	$16,748	$645,690
Less Residual Value ($610,000 x 20% x .564474)								68,866
								$576,824

EXHIBIT B

ADPE SYSTEMS LIFE COST BY FISCAL YEAR

	0	1	2	3	4	5	6	TOTAL
1. **Purchase Basis:**								
a. Purchase Cost	$610,000							$610,000
b. Maintenance of Gov"t-owned Equipment								
1st year (9 mos.-after 90 day guarantee)		$22,253						22,253
2nd year			$29,670					29,670
3rd year				$29,670				29,670
4th year					$29,670			29,670
5th year						$29,670		29,670
6th year							$29,670	29,670
Total a - b	$610,000	$22,253	$29,670	$29,670	$29,670	$29,670	$29,670	$780,603
Adjustment Factor	1.00	.909091	.826446	.751315	.683013	.620921	.564474	
Adjusted Total	$610,000	$20,230	$24,521	$22,292	$20,265	$18,423	$16,748	$732,479
Less Residual Value								
(610,000 x 20% x .564474)								($68,866)
Total Cost								$663,613

EXHIBIT C

ADPE SYSTEMS LIFE COST BY FISCAL YEAR

	0	1	2	3	4	5	6	TOTAL
1. Lease to ownership plan (Title transfer at the end of six years)								
Lease $12,000/month including maintenance								
a. First year		$144,000						$144,000
b. Second year			$144,000					144,000
c. Third year				$144,000				144,000
d. Fourth year					$144,000			144,000
e. Fifth year						$144,000		144,000
f. Sixth year							$144,000	144,000
Total a - f		$144,000	$144,000	$144,000	$144,000	$144,000	$144,000	$864,000
Adjustment Factor	1.00	.909091	.826446	.751315	.683013	.620921	.564474	
Adjusted Totals		$130,909	$119,008	$108,189	$ 98,354	$ 89,413	$ 81,284	$627,157
Less Residual Value ($610,000 x 20% x .564474)								($ 68,866)
Total Cost								$558,291

REMARKS ON EXHIBIT D

1. The present value cost is determined by using a discount rate of 10% carried to six decimal places and assumes end of year costs. The discount factor for the last month of each year was used (i.e., 12 months - .909091; 24 months - .826446; 36 months - .751315; 48 months - .683013; 60 months - .620921; 72 months - .564474) for the sample analysis. In an actual economic analysis, the preparer would use the applicable discount factors provided by their department.

2. Six year systems life.

3. Straight six year lease; residual value not applicable.

EXHIBIT D

ADPE SYSTEMS LIFE COST BY FISCAL YEAR

	0	1	2	3	4	5	6	TOTAL
1. Straight Six Year lease $11,000/month including maintenance								
a. First year		$132,000						$132,000
b. Second year			$132,000					132,000
c. Third year				$132,000				132,000
d. Fourth year					$132,000			132,000
e. Fifth year						$132,000		132,000
f. Sixth year							$132,000	132,000
Total a - f		$132,000	$132,000	$132,000	$132,000	$132,000	$132,000	$792,000
Adjustment Factor	1.00	.909091	.826446	.751315	.683013	.620921	.564474	
Adjusted Total		$120,000	$109,091	$ 99,174	$ 90,158	$ 81,962	$ 74,511	$574,896

SUMMARY SHEET OF EXHIBITS A-D AS COMPUTED UNDER THE PRESENT VALUE DISCOUNT METHODOLOGY

Alternative Methods of Acquisition Depicted	Systems Life Cost Exhibits A - D
A. Lease basis with option to purchase (option exercised at the end of 18 months)	$576,824
B. Purchase Basis	$663,613
C. Lease to ownership plan (Title transfer at the end of six years)	$558,291
D. Straight Six Year Lease	$574,896

The exhibits are designed to depict the alternative methods of acquisition using the present value discount methodology. No attempt has been made in these exhibits to identify all costs associated with the acquisition of ADPE. In an actual economic analysis, cost to the Government includes not only the vendor prices (equipment, software, and support) over the systems life, but also predictable inhouse expenses for ADPE installation and operation.

3.4 <u>Economic Analysis</u>

An economic analysis is the process used for analysis and documentation of the relationship between data systems and the functional operations supported by these systems. (8, C-1) It has been separated into discrete steps for convenience of presentation; however, it will be noted that significant interplay exists among these steps in practical application. While it is realized that this discussion goes beyond the computer evaluation itself, a manager must obviously relate it to the overall operation which it is to support.

The following information concerns items of interest in an economic analysis.

a. Problem/opportunity identification.

The problem should be presented in terms of the current functional deficiencies which are targets for improvement through automation. The initial problem statement should be subjected to continuous review as part of the ensuing steps in the process, since it will undoubtedly undergo several major changes as a result of the iterative and interactive nature of the process.

b. Relevant environment.

Describe the functional environment and operations that the proposed system is to support. The environment, description of existing resources, production processes, and products form the baseline alternative and provides the decisionmaker and analyst with a common point of departure. Major processes and associated resources in the area of functional operations to be supported by the automated data system should be identified and investigated.

c. Objectives.

Objectives stated should be specific and related to solving the problems or realizing the opportunities identified in a above. Euphemisms, such as "the objective of the proposal is to provide management with more accurate, timely information," are not applicable objectives.

d. Assumptions and constraints.

Assumptions and constraints are any factors that limit the flexibility of the decisionmaker or which might restrict the use of the analysis in the decision process. Assumptions focus on the key factors, processes, and variables effecting the analysis, but which are not explicitly stated in other parts of the analysis. Constraints are factors external to the relevant environment, but which limit the feasible alternatives to the problem solution.

e. Alternatives.

There is no fixed rule on the number of alternatives that must be considered. However, from the discussion below, it is obvious that it is highly unlikely that there will ever be fewer than two alternatives and a baseline, at least in the earlier phase of system development. Alternatives to be considered involve alternative methods of functional operations as well as alternative methods of providing automated support to these operations.

(1) In general, the selection of a computer is predicted on using ADP to correct a shortcoming or improve operations. This automatically dictates a baseline (no change to the present function) and two other alternatives--one which requires only correction of the shortcoming (minor changes) and one which envisions major changes in either the ADP or

functional procedure.

(2) Other alternatives which must be addressed as appropriate are:

(a) Use of existing services through sharing, consolidation, or reutilization of Government-owned facilities.

(b) Obtaining similar systems or major aspects (applications) of similar systems from other DOD or Government agencies.

(c) Use of contractor support (versus in-house).

f. Costs.

All costs should be identified in the cost portion of the analysis. Costs for each alternative can be considered to fall into three broad categories:

(1) Costs within the alternative that are directly related to automatic data processing (ADP) support.

(2) Functional costs associated with the alternative that would change as a result of implementing that alternative.

(3) Functional costs associated with each alternative as an aid to visualizing the costs associated with each alternative. One should consider representing the relationship of two alternatives by a diagram (fig. 3-1). Let a triangle represent the total cost of alternative A and a rectangle represent the total cost of alternative B. ADP related costs should be identified in total for each alternative. Basic elements of ADP related costs are shown in the sample forms provided at figures 3-3, 3-4, and 3-5. These cost elements are used to describe ADP systems in the program/budget process and economic analyses. These costs must be portrayed

in the analysis in such a manner that if the proposal were adopted, these costs would be identifiable in subsequent program/budget documentation. Functional costs that are common to both alternatives (cross-hatched area, figure 3-1) need not be incorporated in the economic analysis since they are nondifferential. The last category of costs to be identified is functional costs unique to a particular alternative. If alternative A is the "no change" or baseline alternative, the area labled "functional cost unique to alternative A," provides the basis against which the unique functional costs of each of the other alternatives will be compared. Note that the alternative may be greater than, equal to, or less than those associated with the baseline case. In all circumstances, each alternative will be compared to the baseline case so that changes are identified from a common reference point. Identifying cost reductions or decreases in relation to the baseline case constitutes a commitment by the functional manager to absorb corresponding budget reductions at specified points in time. In those cases where functional managers plan to reutilize resources freed by implementation of the MIS rather than absorb reductions in that area, the specific reutilization must be identified. For those functional costs that result in a net increase in relation to the baseline case, sufficient details must be provided to facilitate an evaluation of the impact of the increases. The analysis for each alternative considered will consist of both Part I--ADP Expenses and Part II--Functional Expenses in the formats as shown for each phase of the life cycle of each alternative. Figure 3-2 graphically represents the distribution of cost of a baseline and one proposed alternative over time. Costs have been grouped into the categories of development, phaseout, and operation for the new system. These categories should not be confused with the formal phasing of the system life cycle and are presented only to illustrate one means for viewing total systems costs. Some costs may fall into all three categories in a given year. Costs which have been expended or are otherwise irrevocably obligated to a project are "sunk costs" and should be identified, but excluded from further analysis, i.e., not included in the computation.

g. Benefits.

(1) Benefits are to be expressed in terms of dollar savings resulting from satisfying the objectives of the functional operations supported by an automated data system. The principal task to be undertaken in this section of the analysis is to isolate the quantifiable benefits, in terms of the objectives for each alternative. In many cases it will be first necessary to estimate or measure the change in systems performance parameters identified as demonstrating satisfaction of the system objectives, then subject each parameter to a detailed analysis of the value of obtaining that amount of change.

(2) Data to support the benefit analysis must be identified early in the life cycle of the system in order to permit adequate preparation, collection, analysis, and coordination. Baseline data should be collected early, with updates as required.

h. Compare alternatives.

(1) The comparison of alternatives surfaces the key differences, and enables the decisionmaker to focus on trade-offs. The basic procedures for these comparisons include the use of present value techniques. Only three relationships exist as concerns the cost and benefits

of various alternatives: Equal benefits/unequal cost; equal cost/unequal benefits; unequal cost/unequal benefits.

(2) The unequal cost/unequal benefits case is both the most common and the most difficult. Unless every possible system parameter is identified, measured, evaluated, and translated into some common measure, there is no all-purpose criteria for identifying the preferred alternative.

i. Test for sensitivity.

(1) Derivation of costs and benefits for the various alternatives under consideration may have been achieved largely through the use of simulations, projections, and assumptions concerning the operational environment. No matter how much effort has been invested in the assiduous use of these techniques to obtain an accurate portrayal of the environment, the result may not and probably will not be the same as that environment. If for no other reason, the future orientation of the analysis interjects a certain amount of risk or uncertainty into the results.

(2) The major job in this step of the process is to explore risks and uncertainties with a view to discerning the potential impact of these elements on the outcome of the analysis. This is accomplished by examining the key cost, benefit, and environmental factors and relationships, in light of variations to the stated assumptions. Two analytical techniques are considered useful in carrying out this portion of the analysis: sensitivity analysis and contingency analysis.

j. Presentation of the analysis.

The completed analysis should be structured to facilitate assimilation and understanding on the part of reviewing and decisionmaking authorities. For this reason, use of an executive summary and appropriate graphic displays and tables are useful inclusions to the basic analysis document.

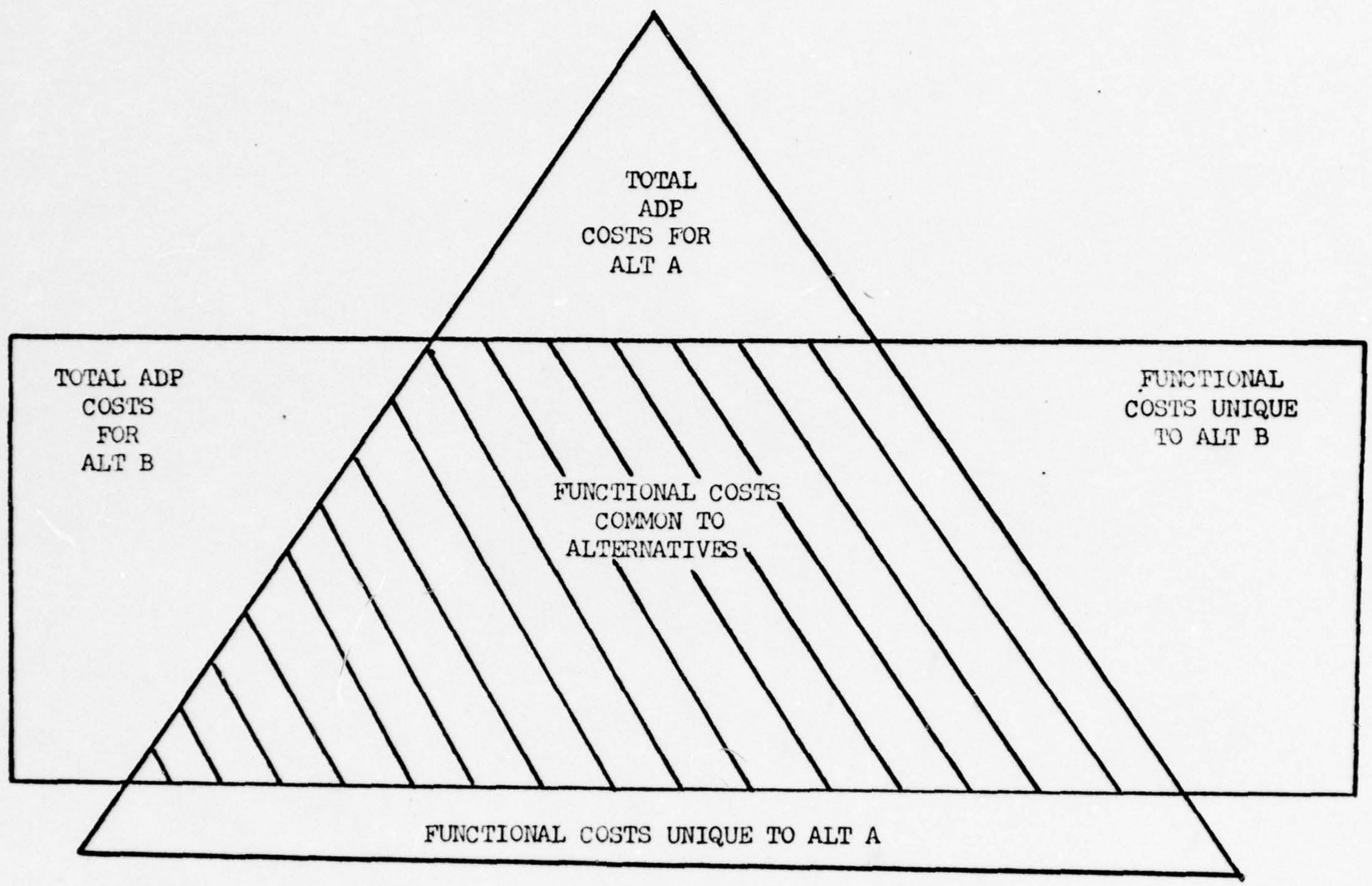

TOTAL
ADP
COSTS FOR
ALT A
TOTAL ADP
COSTS
FOR
ALT B
FUNCTIONAL
COSTS UNIQUE
TO ALT B
FUNCTIONAL COSTS
COMMON TO
ALTERNATIVES
FUNCTIONAL COSTS UNIQUE TO ALT A

Figure 3-1

ADP SYSTEM LIFE-CYCLE COST
(NOT DISCOUNTED)

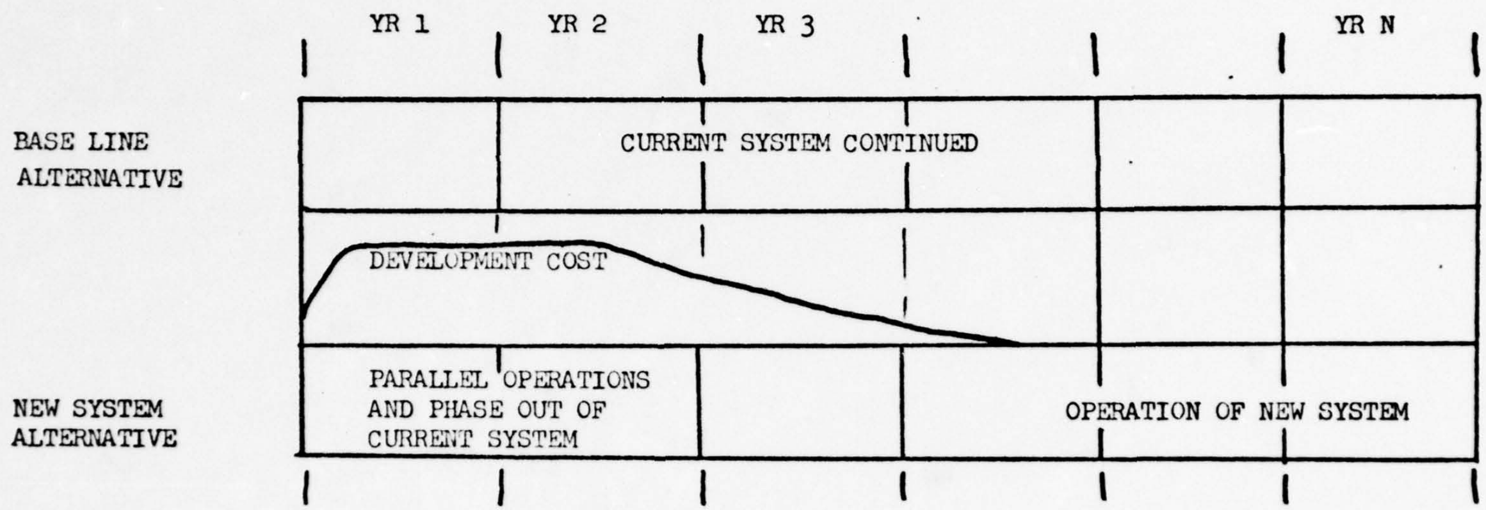


Figure 3-2

ADP PROJECT ECONOMIC ANALYSIS

Part I ADP Expenses							
	Fiscal Year/Milestone Increments						
1. Phase.	Sunk Costs	Current FY	FY____	FY____	FY____	FY____	FY____
In-house Personnel Resources							
a. Civilian Man-Years							
Civilian End Strengths							
b. Military Man-Years							
Military End Strengths							
Capital Investments--Total							
a. Purchase of New ADPE							
b. Purchase of Leased ADPE							
c. Purchase of Other Equipment							
d. Site Preparation							
In-house Operations--Total							
a. Civilian Salaries and Overtime							
b. Military Base Pay and Allowances							
c. Supplies							
d. Other							
Commercial Contract Services--Total							
a. Leased ADPE Rentals and Maintenance							
b. ADPE Time							
c. Systems Analysis and Programing							
d. Maintenance of Owned ADPE							
e. Other							
Inter and Intra Agency Services							
a. Payments to Others							
b. Reimbursement from Others							

Figure 3-3

ADP PROJECT ECONOMIC ANALYSIS

Part II Functional Expenses							
	Fiscal Years/Milestone Increments						
1. Phase Days/Date	Sunk Costs	Current FY	FY____	FY____	FY____	FY____	FY____
In-house Personnel Resources							
a. Civilian Man-Years							
Civilian End Strengths							
b. Military Man-Years							
Military End Strengths							
B. Capital Expenses							
1. Equipment purchases							
2. Other capital expenses							
3. Total capital expenses							
In-house Operations--Total							
a. Civilian Salaries and Overtime							
b. Military Base Pay and Allowance							
c. Supplies							
d. Other							

Figure 3-4

ADP PROJECT ECONOMIC ANALYSIS

Part III Benefits								
Days/Date & Milestone Increment	Budget Program/ Project	Element of Expenses	Sunk Expenses	Fiscal Year/Milestone Increments				
				Current FY	FY____	FY____	FY____	FY____
A. Personnel Man-Year Reductions								
1. Civilian								
2. Military								
3. Contractor								
4. Total M/Y Reduction								
B. Operating Expenses Reductions								
1. Civilian salaries								
2. Military pay								
3. Supplies								
4. Equipment rental								
5. Other								
6. Total reductions--In-house								
7. Total reductions--reimbursable								
8. Total								
C. Miscellaneous Reduction								
1. Other								

Figure 3-5

3.5 Request for Proposal

Request for Proposal must cover two categories of items for any ADP system. The first category concerns those items which are mandatory. This means that without any part of the items contained under this heading the system would either not operate or the entire system would drop below that which is considered as minimum. The second category covers any item which is not included in the mandatory section. These are considered to be other system requirements (OSR's).

To determine which items are mandatory and which are OSR's may prove to be challenging if several systems have been developed. In this case, it may be best to compare the configurations and designate those items common to all systems as mandatory. In any case, the mandatory items should include only those items without which the planned system would not be either operable or acceptable.

The OSR items should be listed followed by a detailed statement concerning each item. A value statement must be prepared which shows the rationale for arriving at the worth of the item and a template which shows how the value will be distributed. More details concerning this method will be found in Section 3.7, Selection.

The RFP is written only after the system has been configured and the mandatory/OSR items have been determined. In addition the cost values associated with the OSR items must have been established. Several approaches to RFP preparation are possible. Each method with its advantages and disadvantages will be discussed in the following three sections.

3.5.1 General RFP Specifications (Equipment Performance Specifications)

This type of RFP is most probably the easiest for the user to write. This method involves specifying minimum performance requirements for each item, such as memory cycle time, disk size and speed, tape speeds, and printer speeds. This method will invariably result in vendor bias if the specifications are not chosen very carefully. Additionally, this method may not allow variances in individual unit speeds that, when considered as part of the whole process, meet the overall system requirement. However, if the solicitation specifies performance with benchmark, a fair and equitable procurement should result. With this approach, the vendor designs the largest portion of the system, thus allowing him the freedom to configure as he pleases, using the few constraints associated with the given files. The merit of this method lies in the fact that the vendor's analyst, hopefully with broad experience, will design the best possible system. As Joslin indicates, it exposes the organization computer requirements to the top vendor analysts. (13c, 9)

There are several problems connected with writing a general RFP. Due to its nature, the user can expect to spend many hours with the vendor clarifying the intent of the various files mode of operation plus a host of other variables. The user is also likely to spend many more hours trying to verify the systems proposed by the vendors to ensure that they will work. The prospective user must either do this or run the risk of buying a system that will not quite be capable of handling the applications it is required to handle. Also, it is very important that the prospective user thoroughly understand the system concepts which the vendor proposes, because no matter which system he selects, the vendor's representative who wrote the proposal and suggested the concept will not be delivered with the system. It will be the responsibility of the user to turn the concept into reality. Depending on the amount of work accomplished in the analysis phase, the evaluation process can be either short and smooth or long and difficult. In essence, it is often difficult to compare competitive proposals and to select one above all the others.

3.5.2 Detailed Specifications (Data Systems Specifications)

The greatest overall advantage in writing such an RFP is the fact that detailed thought processes which must go into each step. The user is forced to inspect his entire system. He must spell out each step to be taken in each of the applications. This method includes establishing the objective of the system and presenting the data processing requirements for accomplishing the objectives. The following data are required: (8, K-3)

a. Throughput requirements

b. File description, record size, etc.

c. Transaction volume and descriptions

d. Card and printer I/O volumes

e. Terminal I/O volumes

f. Information on sequence requirements

g. Timing or turnaround restrictions, etc.

The prospective user must take great care in writing detailed specifications to ensure that they do not become machine-oriented rather than application-oriented. Machine-oriented specifications may discriminate against some vendors, and thus unintentionally keep the company from getting the system that would best meet its needs. Detailed specifications require the vendors to configure their systems exactly as demanded by the specifications. This simplifies systems design work for the vendors, but allows them little, if any, freedom to fit the applications to their computers. Rather the computers must be fitted to the applications. The advantage here is quite obvious. The user detects omissions, errors in description, and inconsistencies.

Detailed specifications offer another definite advantage to the user in that they describe the situation completely and they define each application fully and uniformly to all vendors. Thus the user has to waste little time in talking to vendors. When the proposals are submitted, the user can more easily verify, compare, and evaluate them, since the systems proposed must all be identical to steps set forth in the specifications. No system will be proposed that is far inferior to the system demanded by the specifications. On the other hand, no system will be proposed that is far superior to the system specified, either.

This method, however, also has its drawbacks. The time and effort expended in the writing may be too costly for the system which is to be acquired. Another major point is the fact that the detailed request allows the vendor little improvement on the basic design. As Mr. Joslin stated, "When detailed specifications are used, the system proposed will be no better than the system described in the specifications, but the trouble involved in obtaining the system is minimized." (13c, 11)

Specifications (Data & Performance

are a mixture or synthesis of both of
using both the general/detailed spec-
zation many of the advantages with as
either method. Combination specifica-
as guidelines to be followed in pre-
cifications as examples of how the
, 12)
used as examples serve a threefold

ely which functions are performed in
many questions a vendor might otherwise

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to all vendors. They also indicate
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vendor or the very busy vendor some-
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l have to think it through. However,
D

the prespective user will be doing
will discover any problem areas th
cations to the vendors. This natu
tions between vendors and user.

Proposals submitted in
tion should all present solutions
forth in the detailed specificatio
inative or exceptional proposal.
should be somewhat simpler than ve
sulting from straight general spec
main objectives of using combinati
problem of proper verification and
little importance compared with ob
puter systems.

Frequently the type of
system indicates the best type of
pose that the application is a sci
problems of a relatively fixed nat
most satisfactory, since there is
the computer in the system. On th
calls for many users to time-share
ments would constantly vary, so th
tailed specifications for such a s
desirable even if they could be pr
prospective user is really seeking

The vendor's responses should follow a preselected format. The Government Services Administration's Guidance on the Preparation of Specifications, Selection and Acquisition of Automatic Data Processing Systems of 27 August 1976 offers excellent advice on RFP content. The exhaustive lists offered for RFP preparation, benchmarking, etc., are very good. The prospective user should ensure that he reviews this document in considerable detail. In addition, the same document provides a "Solicitation Document for ADP Systems" which, in essence, is a model ADP contract. The provisions therein apply to all federal agencies.

3.5.4 Request For Proposal Contents

The RFP is the key to a good user-vendor relationship. If the user is willing to accept a response of minimum quality from vendors, the RFP might contain merely a description of the system specifications, a few statements about necessary vendor support of the system, and the due dates for the submission of proposals. Such a bid request might suffice for the purpose, but it certainly does not constitute effective contact with the vendor. A good RFP should contain, at the very least, statements concerning the following elements: (13c, 118)

a. System requirements: This section should contain the requirements of the expected system.

b. Vendor's support of system: This section should contain statements about expected training, back-up facilities, manpower that the vendor is expected to supply, etc.

c. Technical questionnaire and timing tables: These questionnaires and tables seek to elicit information on hardware, software, vendor support, and equipment cost, as well as data on timing. The prospective user should request that the vendor give references to the vendor literature or to other technical sources in support of all information offered in answer to the questions asked in the questionnaire. The user should also request detailed information to substantiate all the vendor's timing estimates. The questionnaire and the timing tables should be preceded by a concise and forthright explanation of how the information that the vendors furnish will be used. The vendor will thus gain a greater understanding of the questions asked, and he will be better able to supply the information requested. But more important is the fact that the vendor will acquire a degree of insight that will permit him to recognize the intended meanings of questions that might otherwise have seemed obscure to him. By explaining the use to which he intends to put the answers, and why he is asking the questions, the user is in essence telling the vendor how he is going to evaluate the proposal, what factors are important, and what relative importance each factor has.

d. Benchmark data: If benchmarks are to be used, the data for these benchmarks should be supplied.

e. Bidder's conference data: If the system is complex or very costly, a conference should be scheduled to discuss the applications covered in the proposal as well as the evaluation methods to be used. The chosen data should give the potential vendors enough time to prepare for the meeting.

f. Dates of significant events: All critical dates such as proposal due date, awarding date, system installation date, etc., should be included in this section.

g. Provisions for handling questions: Since questions must be expected after the proposal has been released, a central candidate is the Procurement Officer. No member(s) of the evaluation team should be involved since prejudices, both pro and con, toward a particular vendor may ensue.

h. Vendor demonstration: Benchmarks, if any, are usually executed during this demonstration period.

The above items concern the more technical ADP aspects of the RFP. To enable an offeror/bidder to prepare a proposal or quotation, the solicitation will identify all the evaluation factors that are to be considered. The Armed Services Procurement Regulation prescribes the specific format and annexes required for any RFP. These aspects obviously must be followed in preparing such a document. The sole intent of the above was to dwell on ADP peculiar items.

3.6 Validation of the Proposed Systems

Why validate? Mr. Joslin writes that, "the user should assume that the claims contained in the vendors' proposals cannot be accepted at face value . . . the prospective user will find that a vendor interprets statements and requirements so as to favor his own equipment . . . . The vendor . . . may greatly expand and enlarge favorable answers to any question whose answers cannot be factually or physically proved or disapproved." (13c, 63) Although less blunt, Mr. Timmreck points to essentially the same problems. He states that: "The vendor's objective . . . is to maximize his profits . . . . He will often tend to emphasize certain features with respect to which his machine is superior to others. . . . Certain aspects of his hardware and software will be designed to 'lock in' the user, that is, to make conversion away from the vendor's equipment prohibitively expensive. It seems, then, that the ancient adage, 'Let the buyer beware' holds in the purchase of multimillion dollar equipment as well as in the grocery market."

These basic comments lead to the next question. How is a given system validated? Are there any guarantees that the selected system will maximize the stated objectives while minimizing the expenses incurred? Several methods will be described and critiqued in the following pages. Some of these methods are currently in use; some have been discarded, while others are still being further developed and refined.

3.6.1 Mandatory Requirements

Validation of the mandatory requirements is a rather quick and painless procedure--the items and their specifications, as listed in the

RFP, are checked against each vendor's proposal. Additionally an in-house review should be made using current technical data supplied by vendors, ADP Industry Standard reports, etc., to validate all aspects of the proposal. Also oral presentation should be sought from bidding vendors to facilitate elaboration of their proposals. In this case members of the Source Selection Evaluation Board, after reviewing the proposals, will be expected to attend each vendor's presentation. Lastly, those items which cannot be directly validated such as a vendor's promise to supply a given support item, etc., should be very clearly defined in the contract. If the vendor's bid does not meet any one of the mandatory requirements, subject to the above discussion, that proposal is immediately disqualified.

3.6.2 System Timing

Unfortunately, the matter of system timing is not simple or easy. Many articles are available to the reader of computer literature which describe various timing methods and processes. With the help of these methodologies, the user should be able to determine whether or not the system will process the data in a specific amount of time.

Basically, every system timing method relates directly to the workload which the system is expected to process. Factors such as equipment and storage usage, language, order or sequence of jobs executed, and tasks of the type which are expected to be processed must be taken into consideration. Many methods for constructing a drive workload have appeared within the recent past.

Joslin (13a, 27-37) describes a technique for selecting representative benchmarks by classifying the workload according to the type of job and then selecting a combination of jobs to represent the characteristics of each class. Shope et al., constructed a drive workload consisting of jobs selected from the actual workload by statistical sampling and then adjusted this collection until it was considered representative. Wood and Forman (28, 51-55) composed a synthetic workload using Shope's technique and substituting Buchholz's (4, 309-318) synthetic program for each job in the mix. The parameters of the synthetic program seem to have been determined by trial and error. Recent proposals for creating an industry-wide library of standardized benchmarks (H. C. Lucas) (15, 1041-1058) and a library of synthetic modules (R. N. Gamse) (11, 10) may reduce the number of manhours required to code and debug the programs, but there still remains the need for a method of constructing a representative workload from such a collection. Ferrari (10, 18-24) stresses the importance of workload characterization and points out the need for methods of constructing drive workloads that are representative of real workloads. Previous methods of job selection may be convenient, but they may be somewhat arbitrary and inaccurate. (24, 2)

Although each of the above methods differs somewhat in construction, their common element, either stated or implied, is the concept of "representativeness" of the total characteristics of any workload which is expected to drive the system. Even though the analysis of the present system has been painstakingly executed, there is little doubt that the compilation of a representative drive workload with all the characteristics of the "real world" is the most difficult phase in any evaluation and selection of a computer system. The issue of representative drive workloads will be addressed again when "benchmarking" is discussed. Once the drive workload has been built (by any of the above methods) the system can be timed.

a. Add-Time Comparisons

Add-time comparisons were used in the past to measure computing power between two machines. This method was abandoned due to:

(1) Variables in adder circuitry and core storage access time.

(2) Single versus multiple-address organization time was not taken into account.

(3) The method completely ignored any consideration of software. (24, 12)

b. Instruction Mixes

This method attempts to broaden the range of the evaluation. The mix of instructions is determined by the user's application programs. Each of the mixes is simply a weighted average of the execution times for a number of the most commonly used instructions. A weighting factor is assigned to each instruction in accordance with someone's opinion of that instruction's frequency of occurrence in programs of a certain general type. The evaluation is based on multiplying the weight factor by the manufacturer's specifications for that instruction and summing each total. Although more instructions are used by this method, many of the shortcomings of the add-time remained. Several other difficulties exist in this method.

(1) I/O considerations and compiler efficiency is usually ignored. (5, 41)

(2) Instruction overlap facilities are hard to reflect accurately.

(3) The result obtained--a weighted-average instruction time--may be a fair representation for an individual system in a particular application area; however, it is almost meaningless to use in a comparison when the number of insturctions required by each system is not known. (1, 13)

(4) No generally accepted criterion for determining the weights has been established.

(5) Although the instruction sets differ among machines, each must be weighted the same.

(6) In general, the instruction mix method is inappropriate for selection purposes and inapplicable for software evaluation.

c. Kernels

A kernel is a small routine, which is usually quite simple. Further, it is coded in the particular machine's own language. This method was quite an advance over the instruction mix procedure. Some advantages were:

(1) The timings are based on the manufacturer's stated execution time for the instructions that are included in the kernel.

(2) Since the process uses the machine's own instruction set, characteristics unique to a machine could be fully exploited to the vendor's advantage.

(3) The kernel can include more parameters than the previous techniques. (15, 82)

Some inherent disadvantages, however, began to appear when multiprogramming and multiprocessing were used. These are:

(1) Kernels are generally isolated tasks, that is, a kernel may represent the main loop of an application program.

(2) In conjunction with the aforementioned, I/O is not properly measured since the stress is on an instruction set.

(3) Modern systems exhibit great overlap and simultaneity of events and thus a dependence upon the sequence and requirements of the total processing workload. (22, 6)

(4) There is not a single typical kernel, and further there are no accepted or standardized weights for combining kernels. Much effort is required to code and time large numbers of kernels. It is also difficult to determine if equal programming skills were used for each kernel. (15, 82)

In general, kernels have been abandoned for comparative evaluations. The relative power of a system is not necessarily how fast it is internally, but how fast it can perform the complete job. (26, 2081) In any throughput evaluations one must consider the interaction of internal performance, with I/O speeds and facilities, in addition to the most important factor of programming systems efficiency. (1, 14)

Up to this point, methods of evaluating pure processing power have been discussed. Due to their inherent shortcomings, they have virtually disappeared from computer evaluation methods. "Benchmarking" has taken place. The next section will discuss the different types of benchmarks and the pros and cons of each type.

d. Benchmarks

(1) General

Benchmark job streams have been used with increasing frequency for the purpose of improving the present performance of a system, predicting the effects of changing workloads on a system, or sizing and selecting a new computer system. There must be a drive workload that imitates the actual workload with reasonable fidelity. Workload is defined as the collection of all individual jobs and data that are processed by the computer system during a specified period of time. (24, 1) One might define benchmarks as follows: They are mix (or grouping) of routine to be run on several different computer configurations in order to obtain comparative thruput performance figures on the capabilities of the various configurations to handle the specific applications. This definition of benchmarks includes the following three key characteristics: first, the routines are to be actually run on the configuration; second, the total throughput time is important (not just processor time); and third, they are aimed at specific applications.

The concept of "representativeness" of the drive workload has been discussed. To meet the above-cited criteria, three types of benchmarks have been used:

(a) Use of the real workload (live benchmark) without change.

(b) Design a workload (artificial benchmark) independent of the real workload.

(c) Assemble a workload (hybrid benchmark) from parts of the real workload.

(2) Live Benchmarks

The simplest and least costly method is to run the present workload against the proposed system. No problems will be encountered with "representativeness" nor with the relationships between real workloads and benchmarks. This method is quite acceptable if the new system is upgrading an existing one. Even this "ideal" approach has its disadvantages.

(a) Since the live workload is the system and the demands on the system change within a given time frame, how do you choose and group the typical workload so that they will give a fair picture of the system's workload? To overcome this problem, Mr. Joslin gives a detailed, cookbook approach designed to assure that the benchmark is truly representative. (13c, 68-81)

(b) Unless the production programs are written in a higher level language, the entire scheme of a natural or live benchmark will not work since the programs will not be portable. (13f, 278)

(c) Benchmarks are prepared and processed using a variety of procedures resulting in unduly long execution times, unreasonable file volumes, and inconsistent measurement procedure. (18, 4)

(d) Live benchmarks are usually associated with high costs, both to the buyer and vendor, in terms of time and money. (18, 5) Much of this time is spent by the vendor in adjusting the benchmark so that it will satisfactorily run on his proposed system.

(3) Artificial Benchmarks

An artificial benchmark is a program which models a live benchmark. Several methods of artificial benchmarks have already been discussed in detail. Instruction mixes were considered representative of the major functions of that system. The kernel method improved on the instruction mixes, as an example, by taking I/O activity and CPU utilization into consideration. The drawbacks to these methods were discussed in the previous section.

(4) Hybrid Benchmarks

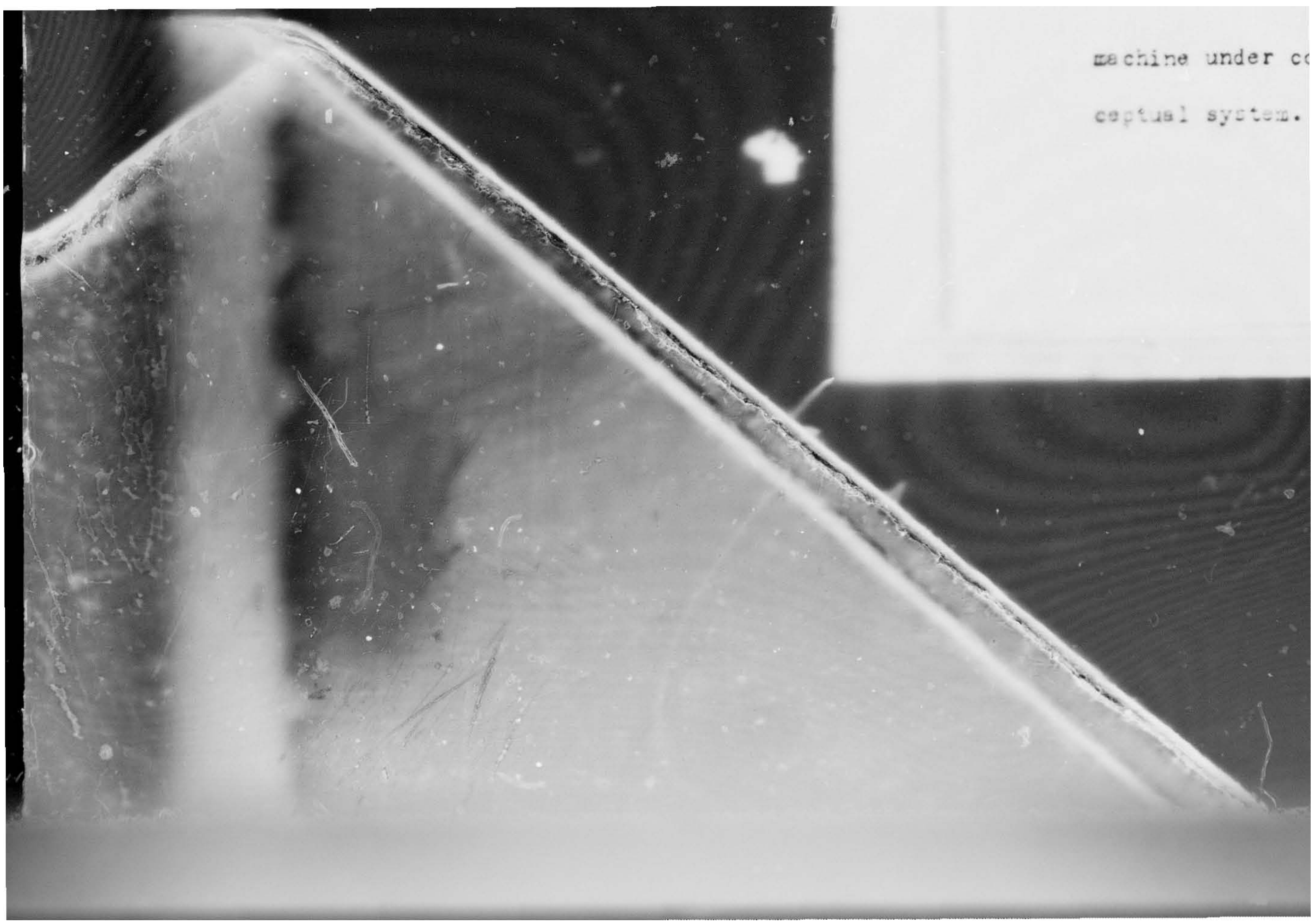
As the term implies, a hybrid benchmark is a combination of methods used to evaluate a proposed system. In most cases, live benchmarks form the core of the process. Synthetic programs may then be used to exercise the machine if it is felt that the live data will prove to be inadequate. Both may be supplemented by simulation, particularly in those instances where remote sites or telecommunications are involved. Although this approach seems to cover as many areas as possible, the disadvantages are again found in the relationship of the benchmark to the real and total workload. The problem encountered in synthetic programs and simulation will be discussed next.

e. Synthetic Programs as Benchmarks

A synthetic program may be defined as a job whose usage of various resources may be parametrically changed to fit the characteristics of a real workload. The programs may be sorted in two groups:

(1) The synthetic program, which is to represent a real program, is designated as the task-oriented element.

(2) Those synthetic programs which can be adjusted to utilize various amounts of CPU time, I/O time, etc., are defined as resource-oriented elements.


machine under co
ceptual system.

The building of a synthetic benchmark is based on a "representative" sample of the workload and production programs of the present system. Their characteristics--I/O channel activity, CPU time, memory space--are measured. A synthetic job or jobs is then built, using the determined characteristics of the real environment. The goal is to remove complexity while preserving sensitivity. (22, 8)

The principle reason for using synthetic programs is their flexibility. They can be made machine independent and portable because they are written in a higher level language. Still, problems do exist. One reason for this might be the fact that the characterization of the real workload used to set the parameters of the synthetic job is not adequate. In essence, it does not uniquely determine the performance variables that are to be measured. (10, 22) David W. Lambert cites the following problem: (1) the lack of standard terms and measures across machines; (2) workload determination and representation for conceptual systems; (3) transferability of synthetic programs; (4) workload specification and generation for on-line systems; and (5) effects of new computer system architectures on present methods. Perhaps Oliver has stated the problem with synthetic programs most succinctly: "It is interesting to note that all suggestions on how to model a workload rely on one of the evaluation techniques surveyed . . . (monitors, simulation, etc.). Thus we should not expect the synthetic mix approach to be an improvement over these." (18, 13)

f. Simulation

A simulator is a program package which represents the actual machine under consideration. This proves very useful for evaluating a conceptual system. Mr. Henry C. Lucas calls simulation "the most potentially application since it is aimed at the IBM 360 system. Within this constraint, however, CSS is a powerful tool for the modeling of computer systems. The language addresses itself to the equipment and its corresponding characteristics. It is generally used to determine the impact of new equipment on the system, changes in the configuration, etc. CSS training is offered by IBM to its customers at no extra cost.

(b) Many simulators which use these and other languages are now commercially available. They will aid the user in evaluating his current system or in evaluating the configurations which are bid by vendors. A description of two popular simulators is provided below.

(1) Systems and Computer Evaluation and Review Technique (SCERT)

SCERT is a proprietary simulation package developed by Comress, Inc., of Washington, D. C. The simulator has been used in a large variety of applications involving feasibility analysis, equipment selection studies, system and program design and system maintenance. SCERT's main advantage lies in the fact that it does not utilize a dedicated language such as GPSS or CSS since the application system definition and the hardware/software definitions are independent. This is quite significant in proposal evaluation. By holding the system definition constant, the equipment configuration can be changed for each vendor. During the system design stage, the converse holds. The SCERT package contains algorithms for optimizing numerous aspects of the total system. This includes the blocking of records on tape or mass storage scheduling in a multi-programmed environment and the assignment of peripherals to I/O channels.

(2) Computer-Aided System Evaluation (CASE)

CASE is a proprietary package developed and marketed by Software Products of Falls Church, Virginia. The package will simulate all types of systems for any manufacturer. The chief advantage of CASE is the program's automatic system design feature. This is quite helpful during the design and evaluation of a new system. By specifying the workload and the desired configuration, a system design will be produced which is independent of any one type of machine.

(c) Simulators have been used to redesign file structures, test the utilization of alternate I/O devices, increase memory capacity by pointing to redundancies and test various workloads on various configurations. Further, many packages are commercially available which are maintained with extensive libraries of manufacturer data for many configurations. Finally, simulators have been extensively used in formal competitive procurements.

(d) Although simulators are enjoying current popularity, due to their flexibility they are expensive both in time and cost. (22, 6)

(e) There are also several other drawbacks. Simulators have shown mixed results for multiprocessor and telecommunication systems. Further, the availability of language and documentation may be difficult since the packages do contain proprietary material. The simulator costs which include training to use the language or simulator and manpower and computer time to build and run the models may prove too great to warrant simulation. Finally, the experience of several users has indicated that simulation cannot be used to make accurate comparisons. Allowances should be made for error bounds of perhaps thirty percent. (26, 209) Since simulators are predictive in nature, their output must be validated and verified. Depending on the complexity of the simulator, this process may prove to be overwhelming.

3.7 Selection

As soon as the proposals have been evaluated and the benchmarks have been completed, the user must make a selection of that computer system which best meets his needs and yet is cost effective. Several methods of system selection have been proposed.

3.7.1 The Weights and Scores Approach

In this approach the characteristics of the proposed systems are divided into major classes such as equipment characteristics, programming, software support, pricing, etc. Subclasses are then established within each class. This division continues until the detail is as fine as desired. The result is a tree structure which completely describes the desired system. This general system is then weighted according to the importance the user places on each node or subnode in the tree. For example, the user may decide that to meet his needs he should represent the central processing unit as being twice as important as memory. He may further rank memory as being as important as the I/O interfaces. He may then, as an example, weigh those characteristics as 2, 1, and 1, respectively. (26, 210) Since the aforementioned items are part of the hardware, a weight is assigned to that category in relation to software, expansion potential, etc. The scoring aspect of this method is achieved by evaluating each vendor's proposal in the above manner. An analyst adds up all the scores for the various branches and nodes. This process continues until the entire system has been evaluated and a single score for each system has been determined. The highest score is ostensibly chosen the winner.

Although this approach is complete and effective several deficiencies are quite evident.

a. The method of assigning weights to the various components is subjective and depends on the individual's understanding of the system, its requirements, the needed growth potential, plus a host of other variables.

b. The entire evaluation scheme is threatened if a particular piece of equipment is not bid. This problem arises since each node (twig) is dependent on the previous node.

c. Another major deficiency of this method is its inability to satisfactorily handle, incorporate, and evaluate the cost of the system.

3.7.2 Cost-Value Techniques

Since cost is among the major factors to be considered in computer systems acquisition, a "cost-value" technique has been developed by Dr. Edward O. Joslin. This method, described in detail below, is currently being used by both the Navy and Air Force.

What is the cost-value technique? Essentially, it is a methodology which recognizes the necessity of evaluating the CSR features of the system and their cost as offered by competing vendors. Those features which have been prescribed as mandatory are not evaluated; rather, they are validated. The payments associated with mandatory requirements are relatively easy to identify, since the vendor itemizes them for the user. Since all vendors must comply with the mandatory conditions stated as Vendor Requirements, which by definition can only be satisfied by the vendor, one must then accept the charges which the vendors attach to fulfilling those requirements. A vendor's ability to meet the mandatory requirements should not require evaluation, since the vendor should not have submitted a bid unless he was able to meet the requirements. However, the degree to which a system or vendor exceeds the minimum requirements is evaluated, if this excess is listed as desirable. (13, 371) The cost-value technique offers two distinguishing features: (1) it enables the user to evaluate any extra features and determine whether these features are important in themselves or if they are merely incidental to the proposed system; (2) it enables the user to assign a dollar value to the OSR. Although the dollar value assigned to a feature may still be an arbitrary choice made by the user, it offers a basis for comparison which can be changed independent of all other individually assigned values.

The first questions to be asked are: What is and what is not considered to be an OSR feature? What cost-value can be assigned to it? To avoid any bias, or appearance of bias, on the part of the evaluation, this study must be initiated before the proposals are received. It thus becomes necessary to deal with hypothetical or realistically anticipated extras. (13, 371) In order to evaluate the expected "extras," categories such as cost, equipment characteristics, expansion potential, and vendor's support of the system are established. Should the vendor include an item which does not fall into any one of the categories which the user has established, a cost-value template can be established at that point if the new item is considered to be important enough.

Some general comments are provided on the four categories listed above:

a. Cost: The cost must be spread proportionately over the expected life of the system, and the system costs must change to reflect the costs of any planned system expansion . . . . No cost item should be duplicative. (13, 372)

b. Equipment Characteristics: The cost-value technique does not consider any equipment characteristics, in themselves, to be important extras. Instead, their significance is measured in terms of the running time of the system which in turn determines the system's cost and expansion potential. (13, 372) Characteristics which fall into this grouping may be hardware compatibility, reliability, capacity, speed, etc.

c. Expansion Potential: In order to evaluate the expansion potential of a system, it is necessary to calculate the running time required by the system to complete all of the required applications. One must also know the capacity of the central processor and, finally, be able to evaluate the special features such as buffering and parallel processing. (13, 373)

d. System Support: The cost-value technique considers the value of the extras offered by each vendor. Joslin suggests that the simplest and perhaps the best method of cost-value assignment is to simply request the other vendors to quote the costs associated with supplying a service. Thus, if one vendor offers 24 hours on-site maintenance, and other vendors do not, it might prove meaningful to ask the other vendors what the extra charge would be. (13, 375)

e. Other Extras: This category is designed to deal with those items which do not fit into any of the other four previously mentioned groups.

After grouping all of the expected extras or CSR's, value statements must then be prepared which list:

a. The OSR feature--a detailed statement of the item to be considered.

b. Rationale--a detailed statement which shows the methods used to arrive at the value assigned to the feature. The value assigned should be considered from four viewpoints:

(1) The cost to the organization in terms of manpower, equipment, etc., of having to do without this OSR.

(2) The cost of obtaining this OSR by in-house programming, cost of extra equipment, etc.

(3) The cost of purchasing this OSR from someone other then the vendor.

c. The templet--a statement which shows how the value will be awarded to varying amounts of the item made available by the vendor.

d. Cost Assessment--this is a statement added after the evaluation which describes how a cost was assessed to the various bidding vendors for the Other Systems Requirement(s).

Value statements are of three basic types and are assessed accordingly.

(1) Statements of those items having a logical maximum value (or assessable cost). Items of this nature are the Other Systems Requirements which are available from an independent source, i.e., software packages, support, etc. If a vendor were to charge an amount in excess of the stated value, the item would be purchased instead from the alternate source (at least for evaluation purposes). Therefore, the highest assessable cost for those requirements is the cost stated in the

templets for these items must identify the cost by describing them as the maximum cost.

(2) Statements of other items having an approximate maximum assessable cost. Items of this nature are Other Systems Requirements which are largely made up of fixed or predeterminable costs, with some cost elements which are dependent upon the systems bid. An example of this type might be the estimated developmental cost for special software, where, if the user were to do it, it would involve manpower (predeterminable cost) and equipment (dependent cost). Items of this type are identified by stating the approximate cost (value) which could be assessed for failure to bid that item.

(3) Statements of a third type involve an item which owes its value strictly to cost avoidance issues. Items of this type are: location of training or test facilities, space requirements, etc. Approximate values are given for these items also, however, the cost assessment becomes whatever they truly cost.

An example taken from Mr. Joslin's book, Analysis, Design, and Selection of Computer Systems illustrates the above points. (13f, 20)

(1) Desirable Features: Accounting Report - Operating System capability for maintaining records of time charges with respect to users and job identification codes.

(2) Rationale: In-house development of an accounting report program would require an estimated one man-year of systems software analyst effort ($20,000); one man-year of programmer effort ($20,000), and $8,000 in computer time. Thus, the total costs are $48,000. The development time would range from twelve to eighteen months. Development of the

program using contractual programming support would cost an estimated $50,000 and consume twelve months time. Therefore, a value of $48,000 will be used.

(3) Templet: A maximum value of $48,000 could be assigned for the desired package. Value will be assigned, however, in conjunction with a qualitative evaluation of the fulfillment of the requirements by each vendor's package.

In order to properly use the Cost Value Technique for evaluation, it is necessary to bring together all of the mandatory requirements payments and Other Systems Requirements payments over the entire system life. In order to do this, four additional points must be considered: system life, present value, residual value, and the various procurement methods available. Each of these items were discussed previously.

3.7.3 Contract Award

Proposals meeting the mandatory requirements and complying with the provisions of the contract will be evaluated and award made to that responsible offeror whose proposal is determined to be the lowest overall cost to the Government, price, and other factors considered for the system(s) life. Cost to the Government includes the offeror's prices (equipment, software, and support) over the systems life, assessments for desirable features not satisfactorily proposed and any predetermined in-house expenses for ADPE installation and operation. Residual value will be evaluated for any system(s) where ownership resides with the Government.

CHAPTER IV

PROGRESS WITHIN THE SELECTION PROCESS

There are no simple, precise, quantitative measures by which one machine can be said to be better than another. Although there is still a large amount of subjectivity involved, real progress has been made in many facets of the selection process. Past experience has shown that wall charts and graphs were inadequate. Progress has been made in assisting the systems analyst by various automated techniques. Similar progress can be seen in machine evaluation techniques. Instruction cycles and add-times were improved upon by the kernel method. With the advent of the multiprogramming/multiprocessing machine, the evaluation process was modified and changed to include live and artificial benchmarks, simulation, and synthetic programs.

The future seems to hold some promising results in store for the evaluator. Task Group 13, Federal Information Processing Standards, has released some guidelines on standard benchmarks. A new system known as Information System Design and Optimization System (ISDOS) is being developed. (6, 193) This effort is striving to analyze the system as a whole--the organization as a single unit rather than just the various parts.

As computer applications are being integrated, techniques for each of the phases of system development are being integrated. A natural extension of computerized problem statements is translation of those statements into programming language statements. The ISDOS project is designed to produce such a system. While completion of the ISDOS project is some time away, a sufficient number of modules have been designed and tested to prove the validity of the approach.

ISDOS consists of four modules. The Data Reorganizer accepts: (1) specifications for the desired storage structures from the physical systems design process; (2) definition of data as summarized by the Problem Statement Analyzer; (3) the specifications of the hardware to be used; and (4) the data as currently exists and its storage structure. It then stores the data on the selected devices in the form specified. The third module, the Code Generator, accepts specifications from the physical design process and organizes the problem statements into programs recognizing the data interface as specified by the Data Reorganizer. The code produced may be either machine code, statements in a higher-level language (e.g., Cobol), or parameters to a software package. These two modules perform, automatically, the functioning of programming and file construction. The final module of the ISDOS system is the Systems Director. It accepts the code generated, the timing specifications as determined by the physical design algorithm, and the specifications from the Data Reorganizer, and produces the target information system. This system is now ready to accept inputs from the environment and produce the necessary outputs according to the requirements expressed in the problem statement.

Major projects such as these will allow simpler and clearer analyses. These methods, in turn, will allow clearer evaluation techniques to be developed.

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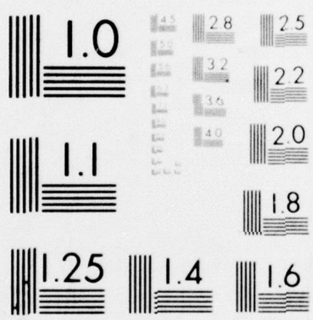

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CHAPTER V

CONCLUSIONS AND COMMENTS

The basic research question that must be answered is as follows: What methods are available to a manager in the evaluation and selection of a computer system or parts thereof?

It appears that the major emphasis which a manager must place in the overall process is on a modification in the initial analysis time. In order to lessen the subjectivism, which is already a part of any evaluation, and to lessen the criticism of "representativeness," considerably more time and effort must be expended at the "front end," of any systems development. Emphasis must be placed on data gathering and analysis of the present system or the proposed system. Techniques have been and are being developed which will aid the analyst in his work. ISDCS was already mentioned as the current effort in systems design. Many of the commercially available simulators must be used in order to evaluate a users present system, as well as the vendor's proposed systems. Conceptual systems do not lend themselves to the present conventional benchmarks. Simulation and synthetic programs, which are representative of the expected process, are two alternatives that are suggested for conceptual systems. This is recommended in spite of the questionable accuracy of simulation and the current nonportability of many synthetic programs. One other alternative must be mentioned. Benchmarks should be run on systems which are similar to the ones which are expected to be bid. Although this is not as satisfactory as an actual run on the bidders equipment, a rough estimate can be obtained from this experience. Finally, the system will perform as expected if time and care are taken in the analysis efforts as well as a careful usage of the various evaluation methods.

Throughout this report I have attempted to maintain a general approach to the problem. Computers, however, are used in almost all programs yet they continue to receive inadequate attention. Witness the tragic failure of the U. S. Air Force logistics computer system which was scrapped after 9 years of effort and $250 million. Its failure was attributed to many causes, some of which was the aspect of systems specifications, testing, and computer acquisition. Any program manager (PM) or similar individual who is charged with development of a system, be it a weapons system or a computer system, must utilize many of the areas contained in this paper. In essence, a variety of subjects have been presented from which a diligent PM can pick and choose as the situation and applicable procedures allow.

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