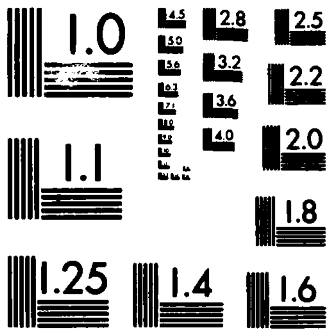
AD-A171 340 COST ESTIMATION FOR REPLACEMENT OF LARGE COMPUTER SYSTEMS CHANGE OF VENDORS(U) AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH M C COBBLE 1986 1/2

UNCLASSIFIED AFIT/CI/NR-86-126T F/G 9/2 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

AD-A171 340

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER AFIT/CI/NR 86- 126T	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Cost Estimation For Replacement Of Large Computer Systems: Change of Vendors		5. TYPE OF REPORT & PERIOD COVERED THESIS/~~DISSERTATION~~
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Mary Caroll Cobble		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS AFIT STUDENT AT: Trinity University		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS AFIT/NR WPAFB OH 45433-6583		12. REPORT DATE 1986
		13. NUMBER OF PAGES 120
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLAS
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

DTIC AUG 29 1986

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

APPROVED FOR PUBLIC RELEASE: IAW AFR 190-1

LYNN E. WOLAVER 18 Aug 86
Dean for Research and Professional Development
AFIT/NR

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

ATTACHED.

DTIC FILE COPY

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

86 8 28 028

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

COST ESTIMATION FOR REPLACEMENT OF LARGE COMPUTER SYSTEMS: CHANGE OF VENDORS

ABSTRACT OF THESIS

Presented to the Faculty of Trinity University
in Partial Fulfillment of the Requirements

For the Degree of

Master of Science in Computing and Information Sciences

By

Mary C. Cobble, B.S., M.S.

In the last few years many aspects of computers and computer science have progressed from "black art mystery" to a precise science. One of the "black arts" that still remains is the ability to correctly estimate the cost of upgrading or expanding data processing operations, particularly those resulting in the changing of vendors.

The federal government has been particularly plagued by gross underestimation of large-scale conversion costs in the past. Management responsible for making sound, economical decisions often lacks the experience in cost estimation needed to even include all the factors necessary for consideration when procuring new equipment. This thesis provides a guide to the manager/analyst who

must develop a cost estimate to be used to select among competing vendors. Current cost estimation techniques are reviewed within the framework of government purchasing regulations and guidelines affecting computer procurement. Separate sections discuss intangible factors and their importance to the selection process.

This background sets the proper perspective for the thesis' case study, which provides the basis for a post-implementation development of a list of intangible factors. An approach is also developed to identify and evaluate intangible factors; this suggested approach can be tailored and applied to other similar computer system purchases.

ACKNOWLEDGEMENTS

The author wishes to acknowledge that this effort would never have been completed without the support and guidance of her Thesis Committee Chairman, Dr. Clifford J. Trimble. Special thanks also to Dr. Gerald Pitts and Dr. George Thompson for their efforts and willingness to serve as members of the Thesis Committee.

Finally, my love and appreciation to my husband, Bill, who has put up with my work habits and has been a constant source of support and encouragement over the years.

TABLE OF CONTENTS

Chapter

I. INTRODUCTION 1

Statement of the Problem 2
Objective and Scope 4
Limitations 6
Assumptions 6
Organization of the Study 7

II. ADP ACQUISITION POLICY AND PROCESS 9

Historical Perspective 10
Regulations 12
Guidelines and Policies 15
ADP Acquisition Process 18

III. CURRENT METHODS OF VENDOR SELECTION 25

Cost/Benefit Analysis 28
Weighted Score 34
Payoff Matrix 38
Cost-Value 45
Interactive Financial Planning System 49
Weighted Evaluation of Cost Factors 52

IV. ESTIMATION OF INTANGIBLE COSTS AND BENEFITS . . 56

Checklist Approach 57
Reducing Subjectivity in Estimation 61
Measurement of Intangible Factors
Related to Computer Growth Stages 63

V. CASE STUDY 67

Background and Purpose of Study 67
Development of Intangible Factor
Profile and Worksheet 69
Validating and Quantifying Profile 76
Interpreting the Results 81
Assumptions and Limitations 84

VI. CONCLUSIONS AND RECOMMENDATIONS 85

Lessons Learned 85
Recommendations for Further Research 87

APPENDIXES
A. Axelrod's Cost and Benefit Tables . . . 89
B. Hussains' Weighted Score Table 97
C. Martin's Payoff Matrix Checklist 99
D. Brocato's Master List 101
E. Smith's Benefit Profile Chart 105
F. Intangible Factor Profile,
Worksheet, and Evaluation 108

SELECTED BIBLIOGRAPHY 116

LIST OF TABLES

Table

3.1 Cost Items 31
3.2 Worksheet for Weighted Score Method 36
3.3 The Payoff Matrix 39
3.4 Conversion of Rankings to Numerical Weights . . 40
3.5 Subfactor Weights for Vendor Services 41
3.6 Value Template for Delivery Dates 47
3.7 Cost Calculations for Selection of DBMS 48
3.8 Intangible Rating Evaluation for ABC System . . 53
3.9 Weighted Evaluation of Cost Factors 54
5.1 Major Headings from Intangible Factor Profile . 72
5.2 Category 10 from Intangible Factor Profile . . 72
5.3 Top Portion of Intangible Factor Profile . . . 74
5.4 Bottom Portion of Intangible Factor Profile . . 76
5.5 Categories 3 & 15 from the Intangible Factor Profile 78
5.6 Category 9 from the Intangible Factor Profile . 80

LIST OF FIGURES

Figure

3.1 Burch's Variety of Categories by Cost 30
3.2 Matrix Model - Converting Subfactors to Grand Weights 42
3.3 Matrix Model Expanded 43
3.4 Solution of Payoff Matrix 44

CHAPTER I

INTRODUCTION

> Man's victories over nature, in science and engineering, are closely correlated with his ability to measure whatever he is working with. This is related to the ability to recognize and measure all the critical factors involved.
> [17, p.15]

Change seems to be a way of life for productive Data Processing (DP) shops. One of the biggest changes is the upgrading or replacement of the computer system. Often the mere thought of a computer system conversion "strikes fear in the heart of a DP manager." [30, p.13] Since ignoring the need for a new system is not a viable option, the replacement of the current system is an inevitable fact-of-life that must be planned. Evaluating and acquiring a new computer system requires a clear picture of the costs involved. The selection of a cost-effective computer system involves the ability to identify and measure the critical factors, including those factors which are difficult to measure.

The Federal government uses computers in virtually all phases of its operations, with the Department of Defense (DOD) being the "largest consumer of computer hardware and services in the government." [24, p.10]

As noted by the Grace Commission, the President's Private Sector Survey on Cost Control, rapid advances in computer science technology coupled with the time consuming Federal acquisition process have resulted in a state of obsolescence for many DOD general purpose computer installations. [24, pp.10-11] Since computer technology is often critical to the ability of the Services to perform their missions, it is mandatory that these obsolete systems be replaced.

Although the government's record for handling large-scale conversions in the past has been reported by the General Accounting Office (GAO) as "dismal", with final costs often exceeding estimations by factors of ten, the GAO is optimistic about future conversion activities. GAO feels that "the root cause of the problems identified was lack of adequate planning and management control..." and that "if all conversion requirements are considered and planned for ... agency officials should be able to make sound, economical decisions about which vendor to choose...". [23, p.17]

Statement of the Problem

Selecting the most economical computer for the job has become increasingly complex with the rapid technological advances in computers, the vast variety of equipment, and the multitude of combinations and possible mixes of different equipment. To evaluate the acquisition of a computer system, one needs a clear picture of the costs involved. Developing this clear picture of costs is difficult even for specialists in the field and could "... require a full-time staff studying models and makes of available equipment." [30, p.51]

The problem of replacement of DOD computer equipment is further complicated by complex and sometimes conflicting regulations, policies, and guidelines governing federal Automatic Data Processing (ADP) acquisition. Funds are often not available to hire outside consultants, and even when outside consultants are used, "in-house personnel will be heavily involved" in planning, developing, and testing during the different phases of acquiring a new system. [23, p.17]

The policy of enhancing the competition for a government contract to produce the best cost savings makes the possibility of each computer replacement resulting in a change of computer vendors a reality. This possible change of vendors needs to be analyzed, using proper life cycle management principles, to select the computer system that will really be the most economical. The key to the development of a correct life cycle cost for each vendor, is "...the identification of all the cost drivers germaine to the acquisition." [24, p.12] If these cost drivers are not all identified or if they are not correctly analyzed, then the lowest bid computer system could turn out to be the most costly choice in reality.

This thesis addresses the problem of correctly identifying and estimating all the costs of computer system replacements, especially those costs which are classified as intangible and are especially difficult to include in system life cycle costs.

Objectives and Scope

The overall objectives of this thesis are threefold. The first objective is to document the existing ADP acquisition environment and its application that results in the conversion of large scale computer systems to new vendors when DOD systems are upgraded or replaced. The second objective is to present a review of current cost estimation techniques that may be used at the vendor selection stage of computer system acquisition. Perhaps the most difficult factors to include in these analyses are intangible factors, so the third objective is to develop an approach to measure intangible costs and benefits. The third objective includes the development of an intangible factor profile, which was developed by studying an actual DOD large computer system acquisition that resulted in a change of vendors. This profile could serve as a guide to future research into developing the best possible estimation of costs to evaluate the proposals of competing vendors.

Specific activities undertaken for this study were:

- Reviewing existing regulatory/policy guidance that directs or influences the acquisition process.
- Reviewing current literature for cost factors and techniques of cost estimation applicable to a large system replacement.
- Identification, evaluation, and inclusion of intangible factors in the cost estimation process.
- Interviews with key personnel to develop case study data.
- Reviewing key documents associated with the case study's history and current status.
- Formulation and validation of a Intangible Factor Profile using case study data.
- Suggestion of possible improvements.
- Suggestion of possible areas for future study.

Limitations

This study is limited to considering only those non-tactical DOD computer acquisitions and excludes the category of computers that is considered critical to direct fulfillment of military or intelligence missions, such as special embedded weapon systems' computers. These special systems are not subject to the same guidelines and directives as the non-tactical systems. Non-tactical systems perform functions much like general purpose business applications. This study is further limited to the investigation of cost estimation when procuring a large computer system, or mainframe; while some of the techniques may be applicable to the acquisition of mini- or micro-computers, that is not the direction of the study.

Assumptions

While private sector companies do not directly parallel the DOD use of computer systems, there is still enough similarity in their use and business practices to assume that findings regarding computer costs in the private sector will be applicable to non-tactical DOD operations. It is also assumed that federal guidelines and policies drive some unique differences between DOD acquisitions, and private sector acquisitions that must be addressed.

Additionally, it is assumed that the inclusion of intangible factors in a cost comparison is highly desirable and achievable, with some degree of accuracy.

Organization of the Study

This thesis addresses the estimation of cost for competing vendors in a large computer system replacement, specificly a non-tactical DOD acquisition. Chapter II sets the background for federal acquisition of ADP equipment by briefly presenting a historical background on federal acquisition, covers regulations, guidelines and policies, and outlines the acquisition process. Chapter III reviews several current cost estimation techniques used for vendor selection found in literature. Chapter IV provides the same type of review for the estimation of intangible costs and benefits. Chapter V presents the case study of a large DOD computer replacement invovling a change of vendors, which serves as an post-installation method of developing and validating an intangible factor profile. Results of the profile are also interpreted in this chapter. The final chapter summarizes the significant findings and potential uses for the estimation techniques and recommends future research directions.

CHAPTER II

ADP ACQUISITION POLICY AND PROCESS

The basic objectives of government and civilian industrial purchasing are similar in that both are supporting operations and trying to buy competitively and wisely from reliable sources. Government purchasing is enough different from industrial purchasing to warrant at least a brief examination of those differences.

The primary difference is the technical nature of many of the products being purchased. Additionally, the source of funds used for purchases neccessitates the use of more constraining procedures designed to protect the interests of the taxpayers. These government procedures "... stem from specific laws and regulations which require competitive bidding, fixed budgetary limitations, rigid auditing of accounts, and the use of prescribed standard specifications." These procedures generally "... allow government purchasing managers considerably less freedom of action and discretion than business allows their industrial counterparts." [12, pp.634-5]

Additionally, when comparing "the nation's largest buyer" to industry, two facts must be remembered. First, the responsibility of defending the nation often makes minimizing costs a trivial issue. Second, our government strives for joint goals of equity and efficiency. The two goals are often conflicting: efficient solutions are frequently regarded as unfair and "...equitable solutions are often regarded by many as hopelessly inefficient." Industry, on the other hand, does not have to address this goal of equity and can "... march to the drummer of efficiency." [12, p.670]

Historical Perspective

Laws regulating government procurement date back to the Second Congress in 1792. Early congressional interest in the excessive profits of contractors and procurement abuses resulted in the 1808 law requiring a clause in every government contract that "... no member of Congress might benefit therefrom." [12, p.635] Graft and favoritism continued, so Congress passed the Procurement Act of 1809 to require that government purchases be made using formal advertising and competitive bidding. [12, p.636]

For the next fifty years, formal advertising and competitive bidding was further defined and expanded. Competitive bidding continued to serve the government well for over a hundred years, in fact today's Congressional mandate continues to be to maximize competitiion and accountability. However, during World Wars I and II, the volume of purchases and the technological complexity of the purchases caused the breakdown of the old competitive process. Congress recognized the necessity of negotiated purchasing with passage of the Armed Services Procurement Act of 1947. [24, p.18]

Since the 1930s depression, the government has also tried to promote socio-economic issues through procurement policies, such as: minimum wage, "Buy America", age-sex discrimination, small business preference, labor surplus preference, and environmental pollution. [24, pp.19-20] The final result has been a complex, confusing, and sometimes contradictory collection of statutes, executive orders, regulations, guidelines, policies, and processes.

After a review of all facets of government procurement in 1972, Congress established the Office of Federal Procurement Policy (OFPP) within the Office of Management and Budget. The OFPP's mandate is "... to develop a uniform procurement system for the federal government, giving consideration to the dissimilar program activities of the executive agencies." The impact of these recent developments can not be measured yet. [12, p.647]

Regulations

The ADP regulatory environment is comprised of: public laws, executive orders, Office of Management of Budget (OMB) circulars, Federal procurement regulations, Office of Federal Procurement Policy (OFPP) publications, Federal information processing standards, Department of Defense (DOD) directives and instructions, and the instructions of different branches of service. [24, p.20] All must be understood and applied when making a government purchase of ADP equipment, but this paper presents only a few of the most significant ones.

The basic law governing DOD procurement is the Armed Services Procurement Act of 1947, which established workable policies for procurement during national emergencies and recognized the method of negotiated procurement under special circumstances. It was clarified in the Armed Services Procurement Regulations (ASPR) which "... governed military procurement, set limitations on the use of certain types of contracts, and emphasized the importance of small business participation in government contracting." [24, p.19] The ASPR is now known as the

Defense Acquisition Regulation (DAR).

Another basic procurement law is the Federal Property and Administrative Services Act of 1949. This act is directed primarily toward civilian agencies; the GSA issued the civilian version of the DAR, the Federal Procurement Regulations, under the authority of this act. Certain sections of these regulations, which include data processing and ADP acquisition, are also mandatory for DOD use. [24, pp.20,25]

One of the most important and well-known laws affecting ADP resources is Public Law 89-306, the Brooks Act. The Brooks Act was based on the principles that "... ADP resources should be procured as economically and efficiently as possible; and only those resources should be procured which are needed and which can assist the management of government programs." [27, p.9] The bill gave the General Services Administration (GSA) "... authority to acquire, operate, fund, and dispose of ADPE for the entire Federal Government." [9, p.13] GSA was not to determine ADPE requirements for the individual agencies.

Over the years the close review of ADPE acquisitions by Congressman Brooks' House Government Operations Committee has pressured GSA to insure maximum competition is possible for ADPE contracts. This "...

over-riding requirement for maximum competition..." has forced elimination of cost cosiderations, like software conversion, when making proposals and evaluating vendors. [9, p.13] The DOD has sought exemption from the act and received partial exemption in the 1982 Defense Authorization Act, but mainly for equipment and services for intelligence, cryptology, command and control, or weapon systems. [27, p.12]

The 1980 Paperwork Reduction Act gave OMB the authority to draft government-wide systems acquisition policy and established the Office of Information and Regulatory Affairs "... as the focal point for leadership and central direction of Federal information resource management. [24, p.22] The 1985 Competition in Contracting Act "... requires the use of full and open competition as the primary method of procurement." [27, p.12] In April of 1985 the new unified Federal Acquisition Regulation became "... the basic set of procurement rules for virtually all federal agencies' acquisition of equipment, supplies, and services." [5, p.32]

Finally, each of the Services has its own specific sets of instructions or regulations guiding acquisition, management, and utilization of ADP resources. Presentation of each specific branch's regulations is outside the scope of this general familiarization with government purchasing, although Chapter 5 mentions some specifics in the case study.

Guidelines and Policies

There is perhaps a subtle difference between a law, or regulation, and guidelines and policies. Guidelines and policies tend to clarify the intent of the law and to specify implementation. The guidelines and policies for ADP acquisition are grouped for study by the agency which issued them. The hierarchy is similar to that used for regulations, and again omits specifics for the different branches of service, although such guidelines do exist.

Congressional committees have become increasingly involved in monitoring ADP acquisition and use since the passage of the Brooks Act. Federal agencies must submit proposed budgets, major policy, and guidance to the appropriate committees for review. The committees with legislative and oversight authority for ADP are:

- House Committee on Government Affairs (HCOGO)
- Senate Committee on Government Affairs (SCOGO)
- House and Senate Armed Services Committee (HASC and SASC)
- House and Senate Appropriations Committee (HAC and SAC) [24, p.32]

Congressional opinion that the executive agencies have exercised poor management of ADP resources and ineffective implementation of PL 89-306 has resulted in very close scrutinity and oversight of ADP acquisition. Unfortunately, ADP acquisition policy stressed by the different committees has not necessarily been the same over the years. HCOGO has stressed the policy of maximizing hardware competition, while HAC and SASC has championed the policy of lowest total life-cycle cost. Perhaps the most powerful influence has been the HCOGO with its management influence through GSA. [24, p.32]

Executive orders direct organizational roles and responsibilities. Policy functions have been transferred from OMB to GSA and back again through Executive Orders 11717 and 11893, in 1973 and 1975. OMB is responsible for policy oversight and formulation, while GSA's role is to develop policy. In 1982 Executive Order 12352 introduced a third organization, the Office of Federal Procurement Policy (OFPP), into ADP policy formulation and control.

Although OFPP was established within OMB to "... provide overall direction of procurement policies, regulations, procedures, and forms", it allowed GSA to continue responsibility for ADP acquisition policy. OFPP instead turned its efforts toward the development of the new Federal Acquisition Regulations (FAR) which were to consolidate DOD, GSA, and NASA common procurement regulations into a simpler, unified system. OFPP also publishes guidance pamphlets. [24, pp.23,26,33]

OMB communicates policy and procedural guidance through its circulars. In 1965 OMB Circular A-71 identified GSA's responsibilities in achieving increased cost effectiveness in ADPE selection, acquisition, and utilization. Guidance for preparation and submission of annual budgets can be found in OMB Circular A-11, 1978. OMB Circular A-76, 1979, sets forth policies for the government's acquisition of commercial or industrial products (not limited to ADP). Specific guidance was provided for major ADP acquisitions by Federal agencies in OMB Circular A-109, 1976. Implementation of these procedures has been difficult, as it conflicts with certain provisions of the Brooks Act and GSA has not provided specific implementation guidance. [24, pp.24-5]

Under the Brooks Act the National Bureau of Standards (NBS), within the Department of Commerce, was tasked with providing ADP scientific and technical advice to federal agencies and to establish ADP standards. NBS issues many publications relating to numerous functions in ADP, such as "...benchmarking, management of multi-vendor plug-compatible systems, standardization, and security." [24, pp.21,26]

DOD directives, instructions, and manuals provide further guidance in implementing statutory provisions and agencies' policies. By 1985 there were 37 different publications available on ADP acquisition and utilization. To name a few: DOD Directive 5000.1 and Instruction 5000.2 implement OMB Circular A-109 within DOD primarily for major systems acquisitions; Directive 5100.40 established the Assistant Secretary of Defense (Comptroller) as the Senior ADP Policy Official; Directive 7920.1 established technical and functional policy concerning life cycle management of ADP equipment; Instruction 7920.2 supplements 7920.1 and presents processes and procedures for review and decision making during the approval process. [24, pp.26-8]

ADP Acquisition Process

Government acquisition is similiar to industrial acquisition in that first a need for the item must be recognized and justified. Next the appropriate level of authority must approve the need and authorize the expenditure for the item, which means enough money must be available in the budget. Finally, some method must be used to select and purchase the item.

Government acquisition is most unlike industrial acquisition in its lack of flexibility. Government purchases usually require layers of approvals, are governed by a myriad of rules, and must often use restrictive methods of purchasing. Studies by the General Accounting Office have described the current acquisition cycle as "... long, complicated and frustrating ... a major contributor to the obsolescence of federal computers." [9, p.6] Major acquisitions within the services can average over ten years, while non-federal complex acquisitions average under two years. [16, p.2]

To better understand why the federal ADP acquisition process can be so lengthy, it is necessary to know something about approval levels, types and methods of purchasing, and selection of sources. Additionally, it is helpful to know which of these methods is favored.

All potential acquisitions must be prepared and submitted with justification up the chain of command for approval. The level to which submissions must go is related to the estimated expenditure. In the case of a major system acquisition, control can be traced from GSA, through the Comptroller, to the Senior Policy Official for the service, on down through the rest of the services' chain of command, until finally reaching the agency desiring the new system. [24, p.37] Such submissions and approvals involve time to prepare at the initiating level and to evaluate at all the higher levels.

If the acquisition is approved, then the actual purchase steps can be initiated. In the case of a major system acquisition the money will have to be budgeted years in advance of the actual purchase; small ADP acquisitions can be made much faster. GSA maintains many open-end contracts from which small items: printers, software packages, micro-computers, and the like; may be obtained with a government purchase order. These contracts are usually the result of nationwide advertising and competitive bidding. [12, p.642]

In the case of a major system purchase, a Delegation of Procurement Authority (DPA) would be obtained from GSA. The Brooks Act made GSA the sole procurement authority for ADP resources; more specifically, the Office of Information Management within GSA, formerly known as the Automated Data and Telecommunications Service, supervises ADP procurement. Since GSA is not staffed to make the actual procurement, most of the ADP acquisitions are made by the requesting agency via a DPA. The wording of the DPA controls and limits the types of systems, methods, and costs considered by the requesting agency. The GSA monitors the requesting agencies compliance with the DPA's terms, and any violations or variances from the DPA's intent could result in GSA revoking DPA authority. [9, p.13]

Three different methods of purchasing may be used by the government: formal advertising, procurement by negotiation, and sole-source negotiation. Roughly 90 to 92 percent of the total dollar value of military procurement is spent through the negotiation process; the remaining 8 to 10 percent is spent through formal advertising. " 'Advertised bidding' and 'negotiation' have specialized meanings in government purchasing. A knowledge of these meanings is essential to understanding government purchasing." [12, p.647]

Formal advertised bidding involves five steps. First is the preparation of an invitation for bid (IFB), which is "... a complete purchasing package, including all contractural requirements and terms." Second, the IFB is distributed to a large number of bidders. Third is the public opening, reading, and recording of the bids; no bids may be revised or withdrawn at this point. Fourth, those bidders not conforming precisely to the IFB are eliminated; bidders proven to be flagrantly nonresponsible also can be eliminated. Finally, the contract is awarded to "... that resposnsibl[bidder whose price is lowest, provided it is deemed reasonable and most advantageous to the government, all factors considered." [12, p.647]

Procurement by negotiation is much more flexible. Vendors are selected to receive invitations to bid, and bids may be revised and resubmitted during negotiations. Neither the information about the bidding nor number and identity of the bidders is made public. The contracting officer has much more freedom in negotiated bidding and acts more like an industrial buyer. Negotiated purchasing is permitted under the Armed Services Procurement Act; this act lists seventeen exceptions that allow negotiation rather than formal advertising to be used. [12, pp.649-652]

Sole-source negotiation involves a single supplier; it usually starts as competitive negotiation from which the most competent supplier is chosen. This form of negotiation is usually reserved for "... high dollar contracts for major weapon systems ...", representing 75 percent of the total defense dollar. This form of purchasing may also be appropriate for the tactical type of ADP purchases mentioned previously. About 50 percent of defense purchasing is sole-source due to the unique nature of the products being bought; nevertheless, effective competition is "... the most practical single means of establishing a reasonable price." [12, p.652-3]

To summarize the difference between government and industrial methods, industry uses competitive negotiating more frequently and has the freedom to use whatever method seems most profitable.

> Regardless of the financial and business advantages ... Congress simply does not seem to favor negotiated procurement. Most government contracting officers ... use formal advertised procurement whenever possible. This approach to selecting purchasing methods is in marked contrast to industrial purchasing practice and sound purchasing theory. [12, p.657]

Selection of sources is another area with less freedom for the government buyer. "The industrial buyer is free to choose suppliers on the basis of total value", which includes such factors as quality, dependability, service, and attitude toward customers. With formal advertising the source is selected automatically with the lowest bid. Negotiated procurement seems to allow the contracting officer to select the best suppliers, but in reality is "... directly restricted by legislation and indirectly restricted by various procedural requirements." [12, p.657]

Most of these restricting laws have socio-economic goals: Fair Employment Practices Act, Buy America Act, Equal Employment and Opportunity Executive Order, Labor Surplus Program, and Small Business Act. The Small Business Act provides a good example of the impact of these socio-economic laws. Procurement requirements, deemed to have small business applications, can either be totally set aside for small businesses or divided into portions for big and small businesses. The intent of this law is admirable, to see that small businesses receive a fair share of the government's procurement dollar. But, the result is that "... prices paid to small business firms appear to be substantially higher than those paid to big business firms for similar purchases." [12, pp.658-9]

The bottom line of this brief review of the different factors affecting the government acquisition process is that government purchasing "... frequently involves special considerations which usually are not applicable to purchasing in private industry." [12, p.634] This author's reaction to a review of the maze of laws, regulations, policies, guidelines, and preferences is sheer wonder that business is ever conducted!

CHAPTER III

CURRENT METHODS OF VENDOR SELECTION

The preceding chapter describes the complex and confusing regulatory environment that promotes competitive government purchasing, which often results in the change of computer vendors when systems are upgraded or replaced. Although the emphasis is on competition, the government still wants to purchase the most economical computer system. To select the most economical system, the competing systems must be compared in some sort of systematized manner to select the vendor that will provide the lowest life-cycle costs and the greatest value.

The objective of this chapter is to provide a review of several methods, currently recommended in literature, that may be used to compare and select among different vendors. (It is assumed that, at this stage, vendors who do not fill mandatory requirements have already been eliminated.) A special area of interest for this author is the inclusion of intangible costs and benefits into the selection process; a separate chapter on this topic follows the descriptions of current selection methods. These different methods were selected by the author on the criterion of suitability for use to select a large computer system replacement.

Six methods used for vendor selection were chosen by the author for presentation:

(1) Cost/Benefit Analysis
(2) Weighted Score
(3) Payoff Matrix
(4) Cost-Value
(5) Interactive Financial Planning System
(6) Weighted Evaluation of Cost Factors

The first two methods are the best known and most widely used. Cost/Benefit Analysis could be considered the "classic" and its accounting method approach is very familiar to management. The Weighted Score method is often used for smaller purchases because of its simplicity, but has a problem with the subjectivity introduced into the decision when determining the weights.

The Payoff Matrix is, essentially, a sophisticated version of weighted scores that adds statistics and levels of details. It uses a three-dimensional matrix to model the selection problem. The fourth method, Cost-Value, strives to reduce the subjectivity found in weighted score methods and to associate added features to their costs. It is especially useful to equalize differing bid proposals.

The Interactive Financial Planning System (IFPS) is interesting in that it is a computer model using natural language and offers several gaming facilities.

The particular version of IFPS reviewed in this thesis was tailored for use in analysis of government acquisition of large computer systems. The last method, Weighted Evaluation of Cost Factors, presents a simple method to incorporate intangible factors into cost analysis.

The variety of methods are presented in more detail in the following subtopics. The author's objective in presenting such a selection is to provide several techniques currently found in literature that are appropriate for use during the vendor selection stage in computer acquisition. The manager or analyst performing the comparison of different vendors' proposals can select a method which fits his analysis needs and which will also be acceptable to higher management. Some of the methods presented may be too complicated, require too much time, or may not conform to the regulatory environment. The "best" method can only be determined by the individual(s) who will use the method.

The organization of the rest of the chapter is such that the reader, only desiring an overview of methods and the author's evaluation of the methods, may read the introduction to the chapter and the comments at the end of each detailed subtopic. The reader is reminded that the full text on each subtopic may still leave detailed questions unanswered, since the purpose of this chapter is to provide the essence of each method and an evaluation of its use. More details of the methods may be found in the sources listed in the bibliography of this thesis.

Cost/Benefit Analysis

Cost/Benefit Analysis (CBA), or Cost/Effectiveness Analysis, can be found in many sources such as those included in this thesis. [1; 3; 4; 10; 25] It can be considered a classic and could be used at many other stages than just vendor selection.

> To evaluate the acquisition, installation, or development of computer equipment and software, to measure the extent of any improvement in computer-based systems, or to determine the financial requirements arising from planned systems, one needs a clear picture of the costs involved. To further judge the efficiency of computer hardware and software, to determine whether a change in a system is indeed an improvement, or to justify a proposed system as being worth the considerable expenditures envisaged, one needs to define and measure the resulting benefits. [3, p.61]

CBA usually consists of five steps, which may vary slightly from author to author. The essence of the steps is that all costs and benefits must be identified, classified, recorded, estimated, and analyzed for the useful life of the system. Axelrod adds the sixth step of decision to his explanation: [3, p.86]

1 Identification--What are the various costs and benefits that pertain to a specific activity?

2 Classification--How should the various costs and benefits be categorized to facilitate ensuing steps?

3 Recording-- What are the actual (or estimated) magnitudes of the cost and benefits?

4 Analysis--How should the various cost and benefit figures be manipulated to represent the most significant aspects of the activity in terms of the decisions to be made?

5 Interpretation--What is the meaning of the results of the analysis?

6 Decision--What actions should result from a correct interpretation of the results of the analysis?

The first three steps of identifying, recording, and classifying costs seem to have two approaches. In the approach used by Axelrod, the costs and benefits are classified into six categories: [3, p.61]

1 Tangible vs. intangible
2 Direct vs. indirect
3 Controllable vs. noncontrollable
4 Fixed vs. variable
5 Certain vs. uncertain
6 One-time vs. ongoing

Four major headings are defined: Tangible, direct; Tangible, indirect; Intangible, direct; and Intangible, indirect; within these major headings resource types are identified: Equipment, Software, Supplies, Staff, and Space. (See Appendix A.)

In the second approach to classification, Burch categorizes cost by behavior, function, time, and type: (See Fig. 3.1)

Costs by Behavior	**Costs by Function**
1. *Variable Costs*. These costs fluctuate with volume changes in a direct manner. Examples are electrical power and supplies (i.e., if the volume of work increases, the use of electrical power and supplies will also increase). 2. *Fixed Costs*. These costs might vary from period to period, but this fluctuation is not in response to volume changes in a particular period. Examples are depreciation, rent, taxes, and management salaries.	1. *Development Costs*. These are costs incurred to bring something into being or to make something better, more useful, etc. 2. *Operational Costs*. These are costs that must be expended to make something work or perform. The employment of a computer operator involves operational costs.
Costs by Time	**Costs by Type**
1. *Recurring Costs*. These costs are repeated at regular intervals. Examples of these costs are payroll and computer rental payments. 2. *Nonrecurring Costs*. These are one-time costs or costs that will end at some specific point in time. The cost of computer program development is a nonrecurring cost. (The cost of maintaining computer programs is recurring.)	1. *Direct Costs*. These costs represent expenditures that result directly from the proposed system. 2. *Indirect Costs*. These are overhead costs which cannot be directly identified with the elements of the proposed system and are apportioned among various areas in the organization. Examples are rent, insurance, taxes, management salaries, and employee benefits.

Fig. 3.1. Burch's variety of categories for cost [10, p.419]

The major headings within Burch's Cost and Effectiveness Summaries, Table 3.1, are by resource type with the different types of costs combined under the resource heading, although Burch admits that "management is most interested normally in direct costs." Burch's headings are valuable since they establish the fact that the actual bid costs for computer configuration are just one part of the total cost of acquiring a system. [10, pp.421-2]

TABLE 3.1
COST ITEMS [10, pp.422-4]

1. Computer Configuration Costs
2. Environment Costs
   - Power requirements
   - Air conditioning
   - Furniture and fixtures
   - Miscellaneous features
3. Physical Installation
4. Training Costs
5. Program and Program Testing
6. Cost of Conversion
7. Cost of Operation
   - Staff costs
   - Cost of supplies
   - Equipment maintenance
   - Sytems maintenance
   - Power and light
   - Insurance
8. Further Systems Work

Burch classifies benefits as either direct (tangible) or indirect (intangible). Direct benefits are those cost savings "... resulting from the elimination of an operation, or from the increased efficiency of some process." An example of a direct benefit is a decrease of $0.50 per transaction processed by a new system. Indirect benefits are not easy to quantify, but an attempt must be made to identify these benefits and include them in the analysis. An example of an indirect benefit is better customer service. Obviously, both types of benefits must be turned into a dollar value to be included in the evaluation. [10, p.419-20]

Whichever method of classifying is chosen, the recorded costs need to be analyzed for valid comparison. The type of analyses performed and the information that must be gathered will vary. For example, lease vs. buy analysis is usually performed to identify the best option for obtaining the different vendors' equipment. To perform this analysis, information about "... lease charges, purchase price, manitenance schedule and charges, expected useful life, estimated resale value, and specific tax rules and regulations must be gathered." [3, p.91] But since government acquisition directives <u>strongly</u> recommend purchasing all equipment, this type of analysis may not be needed for a government study.

Some commonly used methods of analysis are: (1) Net benefit; (2) Benefit-to-cost ratio (rate of return); (3) Net present value (NPV); (4) Relative net present value (RNPV); (5) Internal rate of return (IRR); and (6) Payback period. [3, p.93] Appendix A contains a table which briefly describes and compares these methods of analysis. More detailed explanations of these methods may be found in Axelrod's Appendix B [3] and Burch's Appendix A [10].

After the results of the analyses are obtained, they have to be interpreted. This step may involve performing sensitivity analysis for values which were used that have a high degree of uncertainty. In simpler words, suppose a computer's estimated resale value was very high for one vendor and caused that vendor to be preferred; however, the high estimate was without a good basis, perhaps just a guess. Then the estimate needs to be varied, in this example lowered, and the resulting effects briefed when the CBA is interpreted. The analysis methods themselves have assumptions and disadvantages (see Appendix B) that need to be specified with the presentation of interpretations of the CBA to management.

The decision step might appear to be quite simple, with CBA presenting the most economical choice of computer system However, the subjectivity of some of the estimated numbers combined with the degree of uncertainty of some of the analysis procedures, usually does not make the CBA answer the unquestionable decision. The final decision may be made "... based on overriding intangible factors" that support the decision-makers intuitive leaning. [3, pp.98-9]

Comments

The Cost/Benefit Analysis method should be studied because it is used so frequently and its accounting procedure methods are very familiar to top management. A full development of cost/benefit analysis is beyond the scope of this thesis, but the author does recommend C. W. Axelrod's Computer Productivity: A Planning Guide for Cost Effective Management [3] for an in-depth study of the topic; or Burch's Information Systems: Theory and Practice [10, pp.418-24] for a briefer presentation of the topic.

A definite disadvantage of this method is the level of expertise needed to apply and interpret the various analyses correctly. For this reason, it may be best to hire experts in the field to develop the CBA; even with expert help, the in-house staff will have to gather a large amount of data and provide estimations. So, another disadvantage is the time and effort to gather all the various information needed; the cost of preparing the CBA must be justified by the importance and expense of the decision. Certainly major system procurements would justify a CBA.

Weighted Score

The weighted score method is one of the most common methods of vendor evaluation to be found in current literature. [10; 20; 22; 30; 33; 38] It is also one of the simplest to understand and perform. It may be used to evaluate vendors that have passed all the mandatory requirements for the new system. The vendors are scored on their ability to provide desired system features. The features are each weighted to reflect the relative importance of each. The vendor with the highest total weighted score is considered the "best" choice and is awarded the contract.

As mentioned before, several authors have written about the weighted score method, or some variation by a different name; but Hussain and Hussain presented the clearest, simplest version. A portion of their Table 6.5 [20, p.110] is used here to explain the weighted score process, as applied to one vendor. The full table may be found in Appendix B.

The list of desired features, or decision criteria in column 1 of Table 3.2, should already have been developed before this stage of vendor selection has been reached. (Prior listing of the desired features ensures that they are not biased toward a particular vendor.) Weights must be assigned to each criterion to reflect the relative importance of each; this is an assigned weight and may vary with different acquisition teams and different acquisitions. In the sample Table 3.2, this team thought that hardware growth needs were three times as important as real-time capability.

TABLE 3.2
WORKSHEET FOR WEIGHTED SCORE METHOD [20, p.110]

		Vendor A	
(1)	(2)	(3)	(4)
Decision Criterion	Weight	Score	Wtd. Score
Hardware			
Meet needs of growth	3	7	21
Throughput/$	5	8	40
Communications	2	4	8
Real-time capability	1	1	1
Storage	2	8	16
I/O interface	2	6	12
Site restrictions	1	4	4
Reliability	3	9	27
Ease of use	1	6	6
Total for hardware			135

The assignment of weights may not be a simple process. There may be much disagreement among the team members as to the relative importance of the different criteria. It may be helpful to have a predetermined plan of how to reach a consensus when disagreement arises, i.e. who has veto power and when/if top management should be called in. It should be remembered though that no matter how carefully these weights are assigned, they are subjective.

Next, the vendors are scored on each decision criteria, column 3 of Table 3.2. Some appropriate scale needs to be set for the scoring; the example in Table 3.2 used a scale of 1-10, with 10 as high. Vendor A rated relatively high on reliability, but very low on real-time capability. Scoring is another activity that is subjective. Subjectivity can be reduced by having experts in the particular areas score them. It is also best if the weight assigned to the item is not known by the scorer, so the scorer is "... not prejudiced by the relative importance" of the item. [30, p.52] "... Fair scoring may require considerable effort, involving literature searches, calculations, and customer satisfaction checks." [20, p.111]

The weighted scores, column 4 of Table 3.2, are calculated by multiplying each of the weights, column 2, by the vendor's score, column 3. The vendor's total weighted score is merely the sum of the individual weighted scores. After all vendors' total weighted scores have been calculated for all areas, the vendor with the highest accumulation of points is the winner.

The weighted score method also appears as an integral part of more complicated methods, like the ELECTRE [33], an on-line decision-aid program based on multicriteria decision theory. ELECTRE facilitates sensitivity analysis and warns the decision maker when one alternative may contain important factors which are rated too low to be a good overall choice. For example, if vendor stability was rated very low, the choice of that vendor could result in owning equipment with no company to back it.

Comments

Weighted score method is probably most appropriately used as a sole decision method for smaller acquisitions. It is also fine for large acquisitions with choices between almost identical costs and features. The major weakness of this method is its subjectivity, although some steps can be taken to reduce subjectivity. Another weakness is the inability to relate the ratings to costs. Even with the weaknesses there are still some features that are better rated than "costed", i.e. vendor stability. The ease of using and understanding this method may make it the best choice.

Payoff Matrix

The Payoff Matrix is presented by Martin as both a model which can be used as a "quantitative tool" and as a checklist for decision making. [29, p.18] He lists the elements necessary to build a payoff matrix: (1) alternatives, Ai; (2) states of the future, Si; (3) probabilities of the states occurring, Prob(Si); and (4) payoffs for each combination of alternative and state of the future, Outcome Ai,Si. [29, p.15] The payoff matrix takes the general form shown in Table 3.3.

TABLE 3.3
THE PAYOFF MATRIX [29, p.16]

Alternatives	States of the Future		
	S1 Prob(S1)	S2 Prob(S2)	S2 Prob(S3)
A1	Outcome 1,1	Outcome 1,2	Outcome 1,3
A2	Outcome 2,1	Outcome 2,2	Outcome 2,3
A3	Outcome 3,1	Outcome 3,2	Outcome 3,3

The generation of the alternatives can be difficult. Usually, the alternatives can best be generated by a team with a wide perspective and sufficient time for "incubation of ideas." In the specific example of choosing a computer, the different vendors being considered constitute the alternatives for the model. [29, pp.15-6]

The determination of states of the future first requires that the planning horizon be specified. The longer the time span, the more difficult it will be to predict the states and their probabilities. Each state's probability is a quantification of the possibility of that state occurring in the future. The probabilities can be statistically computed from a ranking of relative likelihoods. Martin recommends that a heterogeneous group with "... a broad perspective and with time allowance for incubation of ideas" be used to determine states and their relative probabilities. [29, p.16]

Next, payoff values are determined for each combination of alternatives and states. The various factors affecting the selection process are identified and ranked in order of relative importance. The ranks can again be statistically translated into weights. If group consensus over the relative importance of the factors can not be reached, Martin suggests the use of some plan like considering which members input should receive the most importance (i.e., "highest ranking member"). [29, p.16-17]

Table 3.4 displays possible selection factors for the task of selecting one brand of computer from several alternatives. The factors have been ranked and their corresponding weights calculated.

TABLE 3.4
CONVERSION OF RANKINGS TO
NUMERICAL WEIGHTS [29, p.16]

Factor	Rank	Weight
Hardware	3	0.20
Software	4	0.13
Skill/Training	1	0.33
Vendor Services	2	0.27
Management Acceptance	5	0.07
n = 5 factors	k = 15	1.00

Weight = (n - Rank + 1) / k

Table 3.5 shows how the primary factor, Vendor Services, was further subdivided, and weights were calculated for each subfactor. This process allows the dissection of factors down to whatever level of detail desired.

TABLE 3.5
SUBFACTOR WEIGHTS FOR
VENDOR SERVICES [29, p.17]

Subfactor	Subfactor Weight
Education	0.07
Maintenance	0.11
Systems Design	0.04
Trouble Shooting	0.05
Total	0.27

After the weighted factors have been derived, the values must be summarized for each combination of alternative and state. To again return to our computer selection example, each brand is ranked for each subfactor; the ranks will probably vary for each brand as different states are considered. The individual ranks are multiplied by the weights for the subfactors; then summed to produce the Factor Weighted Total, see Figure 3.2. The various weighted totals for the primary factors are summed to find the Grand Weighted Total. (Note: value may be negative when objective is to minimize costs.) [29, p.16]

EXHIBIT 5

CONVERTING SUBFACTOR VALUES INTO GRAND WEIGHTS

State of Nature 1 — Computer C

Subfactor	Weight	Rank	Weighted Rank
Education	0.07	1	0.07
Maintenance	0.11	3	0.33
Systems Design	0.04	3	0.12
Trouble Shooting	0.05	2	0.11
Total	0.27	N/A	0.63

Factor Weighted Total

Factor	Weighted Rank
Hardware	0.53
Software	0.29
Skill/Training	0.74
Vendor Services	0.63
Management Acceptance	0.11
Total	2.30

Grand Weighted Total

Fig. 3.2. Matrix model- converting subfactors to grand weights [29, p.17]

The process just described is graphically depicted in Fig. 3.3.

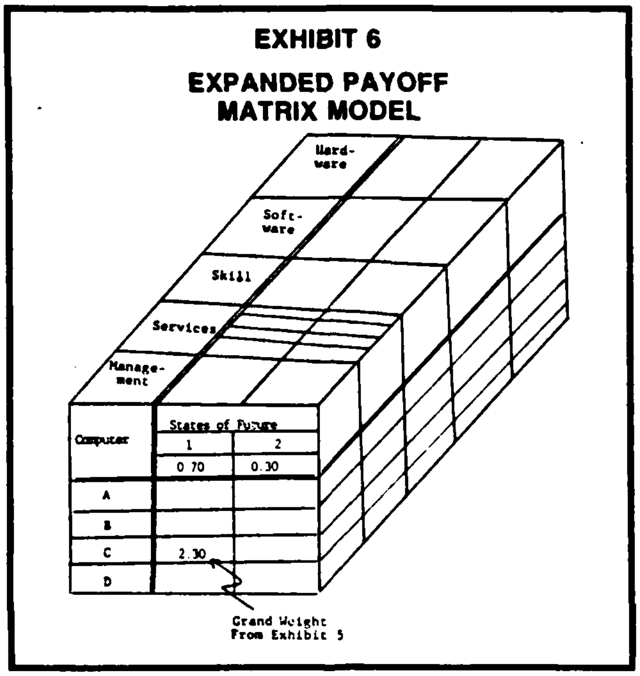


Fig. 3.3. Matrix model expanded [29, p.17]

After all the Grand Weights have been calculated, the matrix can be solved to arrive at expected values for each alternative. Expected values are calculated by multiplying each state's probability by its grand weight and summing the results for each state. The computation for computer C of Figure 3.4 is:

$$(0.70 \times 2.30) + (0.30 \times 1.21) = 1.97$$

EXHIBIT 7

QUANTITATIVE SOLUTION TO THE PAYOFF MATRIX

Computer	States of the Future		Expected Value
	1	2	
	p = 0.70	p = 0.30	
A	2.05	2.63	2.22
B	1.52	2.00	1.66
C	2.30	1.21	1.97
D	3.15	3.00	3.11

Select This Alternative

Fig. 3.4. Solution of payoff matrix [29, p.18]

Martin suggests that the matrix may not really need to be solved to make an effective decision. The systematic framework of the matrix that has forced enumeration of "... all important factors for evaluating our alternatives and to assess the relative importance of these factors" may have already provided the input necessary to make an effective decision. He thinks that the payoff matrix model "... is far more valuable as a checklist for decision making", see Appendix C. [29, p.18]

Martin warned "quantitive addicts" that if the matrix solution is used, to remember that it relies entirely on "... the weights assigned to selection factors and the probabilities given to the states." [29, p.18] He recommended doing sensitivity analysis to discover the most important factors contributing to the ultimate decision. This is done by varying some of the weights and probabilities to see if the decisions are changed. Factors identified as critical can then be further researched to assure that the correct weights and probabilites have been used. [29, p.18]

Comments

This author re-emphasizes that the greatest weakness of this method is subjectivity. Sensitivity analysis should help, but unless this model is on the computer, recomputing the values multiple times will get tiresome and therefore error-ridden. The checklists, multi-dimensional matrices, and the neatness of the "statistically derived solutions" adds a lot of flashiness to what is basically a weighted score method. If weighted score was the best choice for comparing very similar bids, but the boss wants something more sophisticated, then the Payoff Matrix is a good choice.

Cost-Value

Hussain and Hussain present the cost-value method as an "... attempt to equalize bids of features so that costs can be compared. Costs of desired features not included in proposals are added to each vendor's bid." [20, p.112] The cost of each additional feature is added to the orginal bid when a vendor's proposal did not include that feature or subtracted from the original total when a requirement is exceeded. Each additional feature should also have an estimate developed for the option of doing without that feature; this value should be added to the bid if it is less than acquiring the feature.

For example, if a certain software feature is desired but was not included in the vendor's original bid, the life cycle cost of the software should be estimated for purchase, in-house development, and doing without the software. If the purchase of the software plus its maintenance was $19,000, in-house development and maintenance was estimated at $16,000, but the cost of degraded service from doing without the software was only $12,000, then the correct decision, based on cost, would be to do without the software. Therefore, the $12,000 would be the correct estimate to include in the cost-value analysis for this added feature. [20, pp.112-3]

An example of a value that could be subtracted for the overfulfillment of a requirement is promised delivery, Table 3.6. If the equipment is needed by June 1987 and Vendor C can deliver three months early, then Vendor C is given credit for exceeding the requirement by estimating the savings that will result from the early delivery. If the savings is estimated at $2000, then $2000 is subtracted from Vendor C's original bid. Likewise, if Vendor B can't make the date required and will be three months late, costing $4000, then Vendor B will have $4000 added to their original bid. Note that Vendor A's adjustment is zero for on-time delivery.

TABLE 3.6
VALUE TEMPLATE FOR DELIVERY DATES [20, p.113]

	Vendor A	Vendor B	Vendor C
Date of delivery	June 87	Sept 87	March 87
Value	0	+$4,000	-$2,000

Hussain and Hussain included an actual cost-value application for a DBMS acquisition; the case was chosen because the cost-value method works equally well for software, although usually applied to hardware acquisitions. The costs shown are real, but are consolidated into less features and applied to only two vendors. Table 3.7 shows that Vendor B's proposal price was half of Vendor A's, but after the value of omitted features were added, Vendor A's equivalent price was much lower. One of the high costs, conversion, must always be considered when acquiring new hardware too. "The most efficient hardware may turn out to be unacceptable because of such conversion costs." [20, p.114]

TABLE 3.7
COST CALCULATIONS FOR SELECTION OF DBMS [20, p.114]

Cost Items	Vendor A ($000)	Vendor B ($000)
Cost of vendor proposal	$208	$102
Interface to a higher level language; i.e. BASIC	42	18
Natural language query facility with communications interface	20	50
Equipment interdependence (52k/machine)	51	104
Data element dictionary	--	57
Supporting equipment necessary	--	20
Inverted file	--	70
Recovery procedures	--	55
Security	55.5	5
Conversion of data base	34	95
Total	$410.5	$596

The cost-value method reduces the subjectivity of the vendors' comparisons, a problem with scores and weighted value judgments. Some problems with subjectivity still remain "... when estimating the life of a system, the cost of degraded service due to lack of features, or the benefits to be gained from overfulfilled requirements." [20, p.114] Subjectivity could be a greater problem if the cost figures are not carefully and objectively developed by experts.

A major disadvantage, discussed by the Hussains, is the time and effort required to complete the evaluation. The DBMS case, simplified in Table 3.7, actually took a seven-person team three and a half man-years to complete. This was a very experienced, technical team consisting of a head of information systems, a consultant, three systems programmers, and two applications programmers. [20, p.114]

Comments

This author feels that the cost-value method offers a good structured approach for comparing dissimilar proposals, where the basic cost could be deceiving or hidden by additional features that are difficult to compare. The idea of relating value to cost and making a more objective comparison is good; also managers like to see dollar figures. The inclusion of "nice to have someday" features into the basic bid was an approach not found in other authors' work. Furthermore, the Hussain and Hussain text is a good reference for the novice to information resource management.

Interactive Financial Planning System

The Interactive Financial Planning System (IFPS) was selected by LaRue and DeLorenzo for developing a model to study government ADP acquisition. [24] IFPS is marketed by Executive Systems Corporation, Austin, Texas. The advantages of IFPS are:

> IFPS provides for natural language development of financial planning models. In addition to built-in financial, statistical, and mathematical functions, IFPS is capable of performing interactive what if, sensitivity, and goal seeking analyses. Additionally, IFPS is capable of performing risk analysis through simulation (Monte Carlo analysis). The extensive, natural language modeling capabilities and the flexibility of IFPS combined with its availability for a number of different manufacturer's equipment, made IFPS a natural selection for development of the composite model. [24, p.60-1]

The cost model developed by LaRue and DeLorenzo using IFPS was based on three large system acquisitions by the Navy. The output from their model matches the decision milestones used during the various stages of the Navy's life-cycle acquisition process and can "... clearly communicate the real cost of a program to decision makers at each milestone." [24, p.76]

Identifying cost drivers is a critical part of any good economic analysis. Since the cost elements included in the model were extracted from the records of real acquisitions, the costs identified are not just good guesses, but have been verified as real. These real costs have been integrated with costs that will arise from regulatory and organizational requirements, costs which "... are seldom, if ever, accounted for in determining the cost of a project." [24, p.76]

The cost elements are grouped into the following major "modules": personnel; contractor support; other agency or department, material and equipment, and other direct costs. [24, p.127] The major modules are broken down into major categories; for example, personnel costs contains major categories of:

- Project Office Personnel
- Organizational Support Personnel
- Support Activity Personnel
- Executive Review Personnel
- Approval Level Personnel
- Acquisition Processing Personnel [24, p.78]

The major categories are further broken down to cost element structures; within personnel five levels of personnel costs, ranging from clerical to senior executive, may be used.

A final good feature included in the model is the computation of lost opportunity costs. "Opportunity costs were considered to be the projected yearly cost savings attributed to the new system." [24, p.78] Lost opportunity costs were discounted back to the fourth year in this eight year model and added to the adjusted total project cost. This adjustment was provided to "... more accurately (represent) the true costs of the system." [24, p.78]

Comments

The writer of this thesis has provided a very short review of a detailed, well-documented, excellent piece of work. LaRue and DeLorenzo's model looks like one of the best detailed, computer models available. It is especially valuable in that it incorporates governmental regulations and military organizational guidelines into the model. The on-line gaming capability of IFPS also seems like a very promising decision-making tool. The cost of using this model (gathering the information and inputting it, making decisions, and computer time to run the model) will be substantial; therefore, this would only be warranted for a large acquisition project.

Weighted Evaluation of Cost Factors

Vaid-Raizada's presentation of Weighted Evaluation of Cost Factors combines monetary annual costs with weighted ratings of intangible factors into one value, which reveals the best system. The emphasis of Vaid-Raizada's work is on the identification and evaluation of intangible cost factors, which the following chapter discusses further. He has chosen this emphasis because he feels that intangible factors are often ignored or not given due importance, often resulting in the selection of the wrong computer. [40, p.30]

The weighted evaluation method suggests evaluating the intangible factors after the selection process has narrowed down to a few available systems. A simple, seven-step approach is presented to develop the total weighted intangible rating for each possible choice: (See Table 3.8)

TABLE 3.8
INTANGIBLE RATING EVALUATION
FOR ABC SYSTEM [40, p.35]

1	2	3	4	5
1. Ease of use	100	16.67	90	15.00
2. Vendor support	90	15.00	95	14.25
3. Maintenance service	80	13.33	70	9.33
4. Hardware char.	80	13.33	50	6.66
5. Software char.	70	11.67	75	8.75
6. Systems performance	65	10.83	80	8.66
7. Reliability	60	10.00	60	6.00
8. Security	55	9.17	70	6.42
9. Total	600	100.	--	75.07

STEP 1. Make a list of all the intangible factors.
STEP 2. Determine the relative importance of each and list factors from most to least importance, column 1.
STEP 3. Assign an importance value to each, using 100 as maximum, column 2.
STEP 4. Adjust the importance value (to sum) to 100, column 3 figures. (Values in column 2 divided by total of column 2.)
STEP 5. Evaluate each intangible factor for each alternative system. (Other alternatives not shown)
STEP 6. Determine the individual weighted evaluation ratings, column 5. (Multiply column 3 by column 4.)
STEP 7. Total weighted evaluation for each alternative. (Sum column 5.)

Next the costs of each system are analyzed. Vaid-Raizada does not present how initial costs of hardware, software, or installation are derived; nor how to determine annual operating and maintenance costs. His final annual capitol costs are derived using an eight-year life cycle and discount rate of 10 percent. The total annual cost is the sum of the annual capitol costs and the annual operating and maintenance costs for each alternative system. [40, p.36]

The final step is to incorporate the intangible rating into the annual cost figure, arriving at the weighted evaluation figure for each alternative. Table 3.9 shows an example comparing three systems, where annual cost alone would lead to the selection of system ABC. However, when the total annual costs (row 1) are divided by the total weighted intangible ratings (row 2), the results (row 3) reveal system XYZ as the best choice. [40, p.36]

TABLE 3.9
WEIGHTED EVALUATION OF COST FACTORS [40, p.36]

SYSTEM	ABC	PQR	XYZ
1. Total annual cost	$34,601	$37,307	$39,556
2. Total weighted intangible rating	0.7507	0.8054	0.9149
3. Weighted evaluation of cost factors	$46,092	$46,321	$43,235

Comments

This approach is admirable in that it stresses the importance of intangible factors and provides a systematic method to develop those factors and incorporate them into the decision process. The non-specification of the derivation of the total costs is no big problem as it leaves the analyst free to choose his favorite approach. This author is concerned that no mention was made that the subjectivity of the total weighted intangible costs could lead to acceptance of the "best buy" that really wasn't the best. (Varying ABC's intangible rating by +0.05 makes it the best buy!)

A similar approach, called the Brocato Method, was presented by McMillan. [30, part IV, pp.51-6] The weighted score portion of this method was basically concerned with technical rating instead of intangible factors. (See Brocato's list in Appendix D.) In this method, the total rating points are divided by the annual cost to find a "value per dollar figure". [30, p.52]

Both of these methods strive to combine cost factors with those factors which seem to be measured best by some type of rating. This seems to be a good approach, but care must be taken when giving the subjective rating such an impact on the decision.

CHAPTER IV

ESTIMATION OF INTANGIBLE COSTS AND BENEFITS

What is an intangible cost or benefit? Axelrod identifies them as the converse of tangible costs and benefits, "... which can be readily identified and measured." He further elaborates that intangible costs and benefits "... may be easy to identify but difficult to measure, such as the cost of delay caused by a breakdown in equipment ... or may be difficult to even identify, such as the improvement in corporate image." [3, p.63] Intangible costs and benefits, or intangible factors, are very difficult to deal with, so too often they are simply omitted from analysis.

Experts agree that ignoring or improperly treating intangible factors can result in the possible selection of improper equipment or overall bad project decisions. [3; 25; 28; 30; 37; 40] Vaid-Raizada reports that possibly half of all installed computer systems are selected improperly due to inadequate attention paid to intangible factors. [40, p.30] Lay cited an example of a two-year, 1.7 million dollar scrapped project, that even if finished, never accounted for the intangible factor that user expertise was inadequate to ever run the system! [25, p.30] Unfortunately, such horror stories are common. Most systems people either lived through such a story or have heard about system changes that grew out-of-budget and out-of-time due to intangible factors never considered during planning phases. It is easy to find examples of the importance of including intangible factors in the decision process, but difficult to find just how to do it.

While experts have warned that ignoring intangible factors is a common and often disastrous practice, little concrete guidance can be found as to the correct treatment of intangibles during the computer selection process. This chapter incorporates what guidance was available with some of this author's thoughts on the subject. These thoughts are further developed in the following chapter, using data from the case study.

Checklist Approach

Most complex undertakings, and selection of a large computer system would seem to qualify as complex, seem to benefit from some systematized approach. A very common form of systematizing found in the government is the checklist. There are checklists covering everything from how to operate a piece of machinery, to prepare documents for system changes, or to answer a threatening phone call. The checklist leads new troops through intricate steps, serves as a memory jog for experienced people, and provides steps for managers to use for quality control and to chart progress.

This systematic checklist approach seems a plausible way of handling the inclusion of intangible factors in the selection process. There are different types of checklists that would seem appropriate for treatment of intangibles. One might be an overall plan of how to treat intangibles. Another could be a listing of the steps that should be taken to capture information on intangible factors during each step of the selection process. Still another checklist might enumerate all the possible intangible factors, grouped into stages or categories, that have been observed in the past for large computer acquisitions. A final checklist might outline the evaluation process and describe the method for inclusion of intangible factors into the final selection process.

The first checklist to develop is an overall plan of how to treat intangibles. If your company's approach is to ignore them because they can't be quantified, then your checklist will be easy to develop. Otherwise, your selection committee will need to clarify the following:

(1) What is an intangible?
(2) How will intangible factors be reported?
(3) Who will evaluate them?
(4) How do they fit into the selection method to be used?
(5) What level of importance should they receive? (As important as real money factor?)
(6) Will sensitivity analysis be performed?
(7) How will we report this to management?

This list of questions should be addressed at the beginning of the selection process; there may be more questions, and possibly answers, your selection committee can add during a brainstorming meeting on intangibles. The process of looking at the inclusion of intangible factors is important even if the final decision is to not address intangibles due to the difficulty to evaluate them. At the very least, the decision makers will be made aware of the numerous intangible factors that could affect what appears to be the "best" dollar choice.

If the decision is made to include intangible factors, then the second question of how to report intangibles needs to be decided before vendors' proposals are solicited. The same format for reporting and evaluating tangible factors may work with modifications or a new checklist procedure, complete with new forms may need to be developed. (Chapter 5 contains a form for capturing information on intangible factors.)

Ideally the selection committee should compile a master list of all the intangible factors to be included in the evaluation process. An example master list of all possible intangible factors found during research would be an invaluable aid; unfortunately, such lists do not seem to exist. If this is a mature computer system, perhaps this is not the first replacement of the system and past experience will provide some ideas. (Chapter 5 provides a master list from the case study that may provide some suitable starting point.)

After the intangible factors have been identified, then some appropriate measures can be taken to include intangibles in the selection decision. The way intangibles are included would vary with the type of selection method being used. The previously reviewed methods in Chapter 3 ranged from Cost/Benefit Analysis, where all intangible factors would have to be translated into dollars; to rating methods like Weighted Score, where intangibles need only to be rated for each vendor. The conversion of intangibles to dollar figures seems risky at best, since intangibles by definition defy quantifying. Whatever form the intangible takes, it will only be an estimation, but not all estimations are equally good.

Reducing Subjectivity in Estimation

One of the biggest problems of including intangible factors in the selection process is the subjectivity of the values assigned to those factors. By definition, intangibles will always be difficult to quantify; it doesn't matter whether the value assigned is in dollars or a rating, that value will have to be subjective. The goal is to restrict the degree of subjectivity as much as possible. Additional goals are to establish clearly the method of estimation, identify any important assumptions, and indicate the degree of confidence the estimator has in the estimate.

One obvious way to reduce subjectivity is to gain the information for evaluation from sources which have no bias as to the decision. For example, when questioning the vendor on user friendliness of their products the best possible picture will be painted; however, studying impartial user polls from reputable sources will provide a less biased picture. Another possible source of bias could be using an in-house evaluator with a definite preference for a certain product. This person's source of bias could be simple resistance to change or desire to provide "what the boss really wants to hear".

Another simple way to reduce subjectivity is to parcel out the various areas to be evaluated to experts in those fields. The evaluation should be made without information on the relative importance of the factor to the decision process (weight), so the evaluator would not be influenced by the importance of the factor. Evaluators could also be asked to provide best, average, and worst estimates along with the probability that each will occur. Such information can be used to calculate expected values, which are better averages to use for estimation.

Several expert estimates could be averaged. With this technique it would be best to ask each expert to develop their estimates independently, so they will not unduly influence individual decisions. [10, p.421] Each expert should provide the basis for their estimation, if it was just based on experience it should be so identified versus hours of reviewing current literature. The person responsible for combining the estimates may desire to weight some estimates before averaging.

Identifying the probability that the estimation is correct is important no matter how the estimation was derived. Identifying the critical assumptions is also essential. If the assumptions should change during the selection process, then the whole decision may be changed. Intangible factors that were once critical may become of little importance, or vice versa. All interdependencies between factors also need to be specified.

Since intangible factors are the most difficult of all factors to quantify and the most subjective, it seems appropriate to mention again sensitivity analysis. When the final estimates have been derived and included in the selection method, some time should be devoted to studying the effect of varying the values for the intangible factors and watching the effect on the final decision. Management should be briefed on these effects and the conditions which will cause them, so they can make an informed decision.

One final comment on reducing subjectivity, all the suggestions mentioned in this section will cost time and money. Estimates of intangibles will always be subjective, so the amount of time and money spent to improve the estimates should correspond to the importance of the factor to the decision and the total cost of the project. This author calls this the "Good Enough Rule"; in other words, you shouldn't waste too much time and money on the trivial.

Measurement of Intangible Factors Related to Computer Growth Stages

Measurement of intangible factors can be basically divided into two types: either a dollar figure is attached to the cost or benefit, or some sort of ranking comparison is used. The type of measurement tool used to derive and report estimates of intangible factors to management may be linked to the stage of computer development within the organization. Smith developed this idea of matching measurement tools to stages of development for measuring intangible benefits of information systems. [37] While his measurement tools are not unique, their application to intangible benefits is unique. This author will enlarge his ideas to apply also to intangible costs and adapt them for use during the computer selection stage.

Smith's four stages of computer development were: Initiation, Expansion, Formalization, and Maturity. In Intiation, with the first introduction to computers, management will look closely at cost data coupled with a list of intangible benefits. During Expansion, computers have proven their worth and "... budgeting is loose"; managers may only need a "benefit profile" to justify expenditures. Rapid growth and generous budgets are reduced in Formalization; management is more conservative and requires cost data justification for expenditures. In the final stage, Maturity, upper management is more aware of the potential use of computers and trusts the EDP/MIS manager to guide the company in "... terms of a master plan for information resource management." At this stage the "benefit profile" is again appropriate for presentation of intangibles. [37, pp.26-7]

If your organization is in the first or third stage, then a method of measuring intangibles that assigns cost data may be appropriate to use. The assignment of a dollar figure is very difficult; but may also be necessary due to the overall selection method being used, such as Cost/Benefit Analysis, or management's desire to reduce everything to a dollar-and-cents decision. When intangibles must be costed, some of the same techniques used for tangible costing may be useful. Some useful techniques are:

(1) Expected values, using probability to assign savings or costs, to provide a better estimate.

(2) Applying a discount rate to arrive at a more accurate future value of a cost or benefit.

(3) Applying a risk factor to reflect a benefit not being achieved or a cost being exceeded.

(4) Determining a payback period: period required for costs and benefits to be equal.

(5) Determining development time or time required to become fully operational.

If your organization is in the Initiation or Maturity stage, then a ranking method of measurement such as the intangible profile may be most appropriate to use. This author believes that this approach for evaluating intangible factors is preferred, since intangibles by nature defy costing. Smith derived the "benefit profile", a comprehensive checklist of possible benefits that could be used to justify an information system, as part of a corporate research project. (See Appendix E) The idea was to produce a master list of possible intangible benefits to assure that significant intangible benefits were not overlooked. After the applicable intangible benefits have been identified, the benefits can be weighted and ranked for each alternative. [37, p.26]

The same sort of approach can be used to measure both intangible benefits and costs. This is the basis for the development of an Intangible Factor Profile in the next chapter.

CHAPTER V

CASE STUDY

This case study was based on an Air Force unit which recently replaced a very large computer system with one from a different vendor. The name of the unit and the people involved are irrelevant to the study, so will not be mentioned. General characteristics will be supplied, so the reader may determine if this case study is similar to and perhaps applicable to his/her area of interest.

The ideas developed and the views presented are those of this author, and may not necessarily reflect the views of the Air Force or Department of Defense.

Background and Purpose of Study

This particular case study was chosen for a number of reasons. This system is a very large computer system with multiple types of processing requirements and users. This author had firsthand access and experience with the unit during a portion of the replacement process. Most importantly, this replacement was so complex and lengthy that it seemed a fertile ground to discover many of the intangible factors that could later "come back to haunt" the decision maker.

The original system that was replaced consisted of two mainframes, with five processors. The peripherals filled several rooms. Multiple types of processing, such as batch, on-line, and real-time, are supported by this system. The programs total over two-million lines of code. Programs access records in various types of files: fixed, variable, indexed, sequential, and database. Record sizes can range up to thousands of characters; hundreds of thousands of records can belong to one file. The historical tapes range across multiple reels and are maintained for many years. The users of this system span several buildings locally and extend to several worldwide sites.

The replacement process took over ten years and over fifty million dollars, to-date. The acquisition process alone took over six years, twice as long as the total planned replacement time. Once "operational", the new system took three years of parallel processing support before it truly replaced the old system. The new system consists of seventeen processors with eight million words of memory: these numbers address only mainframe capacity and do not include smaller computers in the distributive processing network. These figures have been included only to substantiate the claim that this was a large, lengthy, and complex replacement of computer systems.

This replacement of computer systems did provide many examples of problems. These problems often seemed to be linked to intangible factors which were not allowed to become part of the selection decision. This experience inspired the author to develop this thesis. The purpose of including this case study was to develop a list of intangible factors encountered, especially the most costly ones; and to devise a method of capturing and evaluating intangibles.

Development of Intangible Factor Profile and Worksheet

The impact of ignored intangible factors was abundantly illustrated as the replacement described in this case study progressed. Employees and managers alike would gather and list all the different factors that were combining to make the change of vendors a very costly process. The new vendor had won the contract by being the least costly, but new additional costs were quickly rising. There were feelings running from anger to bewilderment that the old vendor could have lost the bid. Resistance to the new system was high.

The preceding description was the real life situation the author observed, but similar descriptions can also be found throughout computer literature. While this situation was a trying time to live through, it was also a valuable source of insight into the importance of inclusion of intangible factors in the selection process and a good source for collecting a list of intangible factors.

While computer literature did contain horror stories of computer replacements gone bad, it did not furnish much insight into how to handle the problem. Today, industry seldom even considers large system replacement with anything but the current vendor or compatible units. [16, pp.4-6] However, since government acquisitions will continue to driven by the factors explored in Chapter 2 of this thesis, the government will probably continue changing vendors when replacing computer systems. Therefore, the handling of intangible factors generated by a change of vendors is important to government acquisition. Conversely, some of these intangible factors may not be of interest to industry.

Intangible Factor Profile

The development of the Intangible Factor Profile

(Appendix F) was a combination of factors gleaned from literature, interviews with experts, reviews of the case study's documents, and personal experience. There is very little research on this topic, so the bulk of the profile comes from the case study.

The profile is merely an organized list of possible intangible factors. Its suggested use is to provide some examples of intangible factors that may be found during a change of computer systems. The reader may use it to start his/her own list of intangibles or may want to use it to check after-the-fact if anything was missed.

The profile began as a list of intangibles entered just as they were encountered. The list was growing long and lacked organization; the need for categories or headings became apparent. Literature provided a starting point for possible headings; combinations of Robinson's [34] and Vaid-Raizada's works [40] formed the original headings. These were revised and supplemented by information from the case study's documents and interviews. All the major headings may not apply to the reader's situation. (See Table 5.1) Again, these may be selected as appropriate to the reader's needs.

TABLE 5.1
MAJOR HEADINGS FROM INTANGIBLE FACTOR PROFILE

1.	Planning Process	12.	Supplies
2.	Site Preparation	13.	Communications/ Networking
3.	Conversion	14.	Future Expansion
4.	Hardware	15.	Delays
5.	Software	16.	Documentation
6.	Systems Performance	17.	Employee Morale
7.	Reliability	18.	Personnel
8.	Security	19.	Training
9.	Vendor Support	20.	Risks
10.	Ease of Use	21.	Lost Opportunities
11.	Maintenance		

TABLE 5.2
CATEGORY 10 FROM THE INTANGIBLE
FACTOR PROFILE [Appendix F]

10. EASE OF USE

- Degree of difference from old system
  - -- For operators
  - -- For systems programmers
  - -- For other programmers/analysts
  - -- For end users

- "User friendly" rating
  - -- For operators
  - -- For systems programmers
  - -- For other programmers/analysts
  - -- For end users

A word of warning - the placement of individual intangibles under a particular heading may not comply with the reader's ideas of organization. Some individual items were easy to categorize: "Resistance to change" was easy to identify as belonging to "17. Employee Morale". However, most items could easily belong to several different categories. Where <u>did</u> "Degree of difference from old system" belong? (See Table 5.2) It could be considered part of "10. Ease of Use", or was it a conversion problem, or maybe it belonged to training; perhaps it should be a whole new heading.

This author has heard about attempts to include intangibles that were eventually abandoned because intangibles were just so difficult to handle. Don't be discouraged by the indefinite way they categorize. The best bet may be to collect the individual items and then divide them. The central idea is to make their treatment more manageable and to make sure each one is accounted for and not entered multiply.

Intangible Factor Worksheet

The process of developing the Intangible Factor Profile led to the development of a worksheet to capture and track information on intangibles. The idea behind the Intangible Factor Worksheet (Appendix F) was to formally capture information about intangibles as it was discovered and to be able to track and account for intangibles during the course of the acquisition process. The idea is again aimed at systematizing the treatment of intangibles, as discussed in Chapter 4 of this thesis.

The format of the worksheet was purposefully generalized to be useful for either an intangible benefit or intangible problem. (The word problem was used in the place of cost, which implies the ability to assign a dollar cost.) The worksheet's heading may be modified to match whatever categories are being used by the reader's selection process. (See Table 5.3) The idea is to be able to sort the intangibles into manageable groups and treat them much the same way tangible factors are being treated. Creating this worksheet as a database file on a small computer may be a good way to organize this information. All the intangibles can then be retrieved, printed, or checked by category quite easily.

TABLE 5.3
TOP PORTION OF INTANGIBLE FACTOR WORKSHEET

__ BENEFIT	Major Category	____________
	Sub-Category	____________
__ PROBLEM	Factor Number	____________
	Stage/Milestone	____________

The second portion of the worksheet provides space for a title and brief description of the intangible factor. This may be all the information that is captured when the intangible is first discovered, but putting this information on a form that will be dealt with later will insure that the intangible is not lost or forgotten.

The next question, "Related to/Dependent on other factors?", is the place to put relationships and assumptions that may change the effect of the intangible. This section is also the key to determining the answer to "what-if" types of questions for intangibles. For example, in the case study conversion from the old programs, written in a language only supported by the old system, to new programs on the new machine was a $5 million, 70 man-year problem. Contributing to this problem were the related intangible factors of: the unit's inexperience with the new system; the inexperience of the vendor's on-site "experts"; the non-responsiveness of the vendor's off-site experts; coupled with poor, late, and inaccurate documentation. Had any one of those related factors been changed, perhaps the conversion might have been less of a problem.

The bottom portion of the Intangible Factor Worksheet was designed for capturing information during the evaluation or rating phase of the selection process. (See Table 5.4) Again this is just an idea of information that might be helpful, design this part to reflect the type of selection method being used on your project. The idea again is to try to build into the form an attempt to make the estimations or rankings less subjective; this format includes probability figures so expected values may be calculated.

TABLE 5.4
BOTTOM PORTION OF INTANGIBLE FACTOR WORKSHEET

Most likely to be:	Chance of occurring	Dollar estimate (if possible)
__ Slight	________	____________
__ Average	________	____________
__ Above Average	________	____________
__ Very Great Impact	________	____________

Possible Impact: ______________________________

The "Dollar estimate" column of Table 5.4 may be used to actually provide a dollar figure for the intangible; this may be necessary due to the way intangibles are going to be factored into the selection. (Using Cost/Benefit Analysis) Another way to use this estimate is if a solid dollar figure can be applied to this factor, then it should be reclassified as a tangible factor and treated accordingly.

The "Possible Impact" section of Table 5.4 was included to capture a brief statement when the impact was impressive. This could be a very good benefit or a possible disaster statement. These quotes are really helpful and impressive for briefings to management.

Validating and Quantifying Profile

The Intangible Factor Profile was validated in two ways. It was first reviewed for accuracy by several experts working at the case study site. The profile was left with each reviewer for consideration. It was later retrieved during an interview where the author gathered further information. The second validation was performed using information from the historical documents pertaining to the case study. This information was accumulated and entered into the final profile. Both these validation efforts were aimed at assuring that the intangibles listed in the profile really existed.

The quantification step also came from the above two sources. It was quite interesting that many intangible factors started as problems with no real dollars attached, but often ended being connected to lost dollars and time. The two biggest problem areas were conversion and delays. These were followed by communications and hardware, and all these seemed somehow related to vendor support.

Some examples of these problems areas will perhaps give the clearest picture of the impact of these intangible factors. Conversion was quoted as a "monstrous" problem: total cost was $10.4 million, 27 months, or 95 man-years. There were several reasons the conversion costs grew to monstrous proportions. (See Table 5.5) The costs were underestimated: first estimates of 25 man-years were based on only five percent of the old code being converted, the rest being done by a translator. The translator could not be written and finally had to be dropped to allow competitive bidding. (Remember Chapter 2's review of government acquisition!)

TABLE 5.5
CATEGORIES 3 & 15 FROM THE INTANGIBLE
FACTOR PROFILE [Appendix F]

3. CONVERSION

- Degree of difficulty
  - -- Standard languages
  - -- Special languages
- Possibility of being more difficult
- Possibility of taking more time than planned
- Possibility of translators not working

15. DELAYS

- Ability to manage
- Loss of confidence
- Continued leasing of old system
- Extent and possibilities of delays
  - -- Hardware late
  - -- Software releases late
  - -- Vendor not able to fix problem
- Unsuspected complexities in system
- Loss of trained staff (normal rotation, retirement)

Delays were as big a problem as conversion, but more difficult to attach dollar figures to the intangible problems' results. (See Table 5.5) The whole acquisition process was stretched out to six years, often due to having to rewrite specifications to make the bids competitive. The delays continued as the new system arrived: new hardware and software were either not ready for release on time or did not work; and unsuspected problems and complexities were discovered. This all resulted in the continued leasing of the old system for another three years, a much longer time than ever anticipated. There were other spin-offs of the delays; such as loss of the staff that had been trained in the new system, due to normal military rotation, before the new system was ever available for use.

Since the acquisition process took so long, there were many needs that had developed since the specifications for the replacement computer had been written. One especially troublesome area was the needed ability to transmit information at a greater speed than was written into the specifications. The new computer met specifications, but did not have the technology to meet the true need. It also could not be joined into the needed distributive network with other of its smaller machines, because they were not really compatible.

The hardware for the new system was another problem area. Available memory was misleading since it was not usable as a virtual machine. The amount of storage on disk packs was also misleading because of the restrictions placed on their use. The records and files of the existing system were so large that they could not be easily handled on the new system. It was later discovered that the benchmark size of files had been reduced because no vendor wanted to commit that amount of hardware to a full-blown test.

TABLE 5.6
CATEGORY 9 FROM THE INTANGIBLE
FACTOR PROFILE [Appendix F]

9. VENDOR SUPPORT

- Vendor ability to meet deadlines
  - -- Hardware delivery & installation
  - -- Software modifications
  - -- Training
- Vendor reputation
- Stability
- History
- Years/degree of expertise
  - -- Hardware
  - -- Software
  - -- Maintenance
- Knowledge of vendor's staff
  - -- Training/teachers
  - -- On-line help
  - -- On-site technical representatives
  - -- Off-site technical representatives
- Easy to get help
  - -- Type of communication (mail form VS "800" line)
  - -- Speed of response

The one area that had more individual intangible entries than any other was vendor support. (See Table 5.6) This one factor is often cited by industry as the main reason an upgrade of computers is made within the current vendor's line. Many of the problems mentioned before could have been more easily overcome with good vendor support. The vendor's staff needs to be technologically sound, have several years of experience with the products, be able to understand and explain problems, and most importantly, be available! The more difference there is between the current system and the new system, the greater the weight that should be applied to vendor support.

This author could continue illustrating, with even greater detail, the problems listed individually in the Intangible Factor Profile; however, the purpose of this section was just to convince the reader that these intangible factors were real and had a great impact. If the reader has not yet been convinced, then the author suggests checking with other "systems folks" - everyone seems to have their own story quite similar to this one.

Interpreting the Results

The Intangible Factor Evaluation sheet in Appendix F was developed by the author as way to consolidate and report the final results. The evaluation method suggested by this author is basically a weighted score method, with a few new twists. (See Chapter 3 of this thesis for presentation of three weighted score methods.) This method was selected because ratings seem to be a better way to compare intangible factors. If it was easy to attach dollar figures to intangibles, they would not really be intangibles.

One new suggestion is to implement the basic weighted score method using spreadsheets on a computer for the evaluations. The sample spreadsheet in Appendix F shows how intangible factors may be grouped into major headings to provide a total comparison figure for each vendor. The numbers in this spread sheet can be varied and the effect reported. This is an easier way to do sensitivity analysis. Each major heading can also have its own spreadsheet composed of its individual intangible factors. This will aid in computing values for the main evaluation and allow easy sensitivity analysis at the individual factor level.

Another suggestion is to choose a natural rating range with which the evaluators are familiar. This author used a "grading" range: 0 - 100. This approach allows more than one factor to receive a grade of 95 and the final evaluation ratings are adjusted automatically by the spreadsheet. It would be helpful to also provide the evaluators with a standardized guide defining what a "95" score means, so it means the same to all evaluators. This equalization of scoring can be discussed and trial ratings be done by gathering the evaluators together before any actual systems are rated. The real ratings should be completed separately though, as discussed in Chapter 4 of the thesis.

The final use of these composite rating scores depends upon the method of comparison being used for selection. These total intangible ratings could be used to divide the total cost estimates for each system, to arrive at a Weighted Evaluation of Cost Factors. (See Chapter 3) Another possibility would be the combination of these ratings with ratings for tangible factors. A third possibility might be to treat intangibles as a separate section when reporting all the facets of the selection process.

Whatever approach is used to report and include intangibles, it is important that assumptions and dependencies are also reported. The results of sensitivity analysis are also important, especially when coupled with estimations of the likelihood of the ratings being correct. The bottom line is that selection of something as important as a large computer system should not be reduced to looking at some final magic numbers. All the final magic numbers have lots of subjectivity and estimation built in. The managers are paid to use their judgment and make good decisions: all this analysis is not sacred, but just good inputs to be used for making that final decision.

Assumptions and Limitations

Several assumptions were made by this author in the development of the profile, worksheet, and evaluation. First it was assumed that it would still be possible to capture intangible factors important to the selection stage, after the replacement was completed. It was also assumed that a rating method was the best way to evaluate intangible factors. Finally, the author has assumed that the value of publishing a collected list of intangibles is that the captured intangibles will apply equally well to other similar projects.

Conversely, a major limitation of the study may be that the government procurement constraints may generate intangible factors that are unique to that environment. Another limiting factor was the loss of the opportunity to interview some key case study personnel due to reassignment or retirement. The study is further limited by the fact that these suggested methods of treating intangibles have not been applied during a selection situation.

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

This thesis has provided an overview of government ADP procurement, a review of six current computer selection methods, plus methods and tools to use on intangible factors important to the selection. Some of the ideas were not new but being able to find them compiled within one source is new. The methods and tools to use on intangibles are unique, and little other work is available on this topic at this date.

Hopefully, this work will be of value to the analyst/manager needing this background information to start the difficult process of selecting a large computer system's replacement.

Lessons Learned

The heading for this section comes from this author's Air Force background. "Lessons Learned" are the standard heading for collecting all the things you want to do differently if you did the same activity again or maybe just newly discovered realities. There were several lessons learned during the course of this study.

The author was already aware of many differences between government procurement and the way industry does business, but reviewing the literature revealed just how different the approaches could be. For example, industry has no problems buying "sole source", while this way of buying is not accepted by government for the scale of purchase described in the case study. There seems to be justification for buying a large computer system replacement in this manner from the study of literature and this case study. The intangible factors seem to be a driving force in industry's decision to replace large computer systems with the same vendor; perhaps government will be able to adopt this stand in the future.

The author also had suspected that at the end of the thesis that one method of selection would stand out as "The Way" to do business. Instead, the following methods selected and presented for review in Chapter 3: Cost/Benefit Analysis, Weighted Score, Payoff Matrix, Cost-Value, Interactive Financial Planning, and Weighted Evaluation of Cost Factors, were all useful. There are even more good approaches, such as the ELECTRE and Brocato's method, that were not reviewed! No panacea exists for the analyst/manager having to develop a way to select among competing vendors. Selecting the right method is driven by a multitude of factors, ranging from the analyst's experience to "what the boss will buy".

A final lesson learned was that intangibles really are difficult to handle. The author also had a preconceived notion that a little research effort would reveal a way to quantify and evaluate intangibles. There really is no way to fix dollar values on everything; therefore, the decision makers simply must be convinced to include these intangible factors into the decision even though dollar figures may not be attached. Chapter 5 suggested three ways to incorporate a composite rating for intangibles into the decision: Weighted Evaluation of Cost Factors, combined with ratings for tangibles, or a separate report section.

Recommendations for Further Research

The suggestions of how to treat intangible factors during the selection process developed in Chapters 4 and 5 need to be subjected to further research. Specifically, they need to be validated by use during a large computer replacement project and implemented from the beginning of the project.

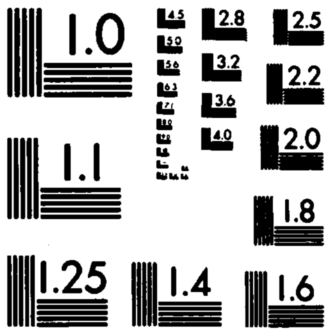
Similar studies need to be conducted to add to the Intangible Factor Profile's list of individual items. Perhaps more research could eventually compile a comprehensive list of factors that the analyst could be assured was valid.

More research is also needed to develop a selection process that is able to discover the mix of dollar figures and intangible figures that result in making the best decision.

Finally, perhaps further research will modify the government's accepted ways of replacing large computers. Perhaps intangible factors will be accepted as a driving force in the selection process.

AD-A171 340 COST ESTIMATION FOR REPLACEMENT OF LARGE COMPUTER SYSTEMS CHANGE OF VENDORS(U) AIR FORCE INST OF TECH WRIGHT-PATTERSON AFB OH M C COBBLE 1986 2/2

UNCLASSIFIED AFIT/CI/NR-86-126T F/G 9/2 NL



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

APPENDIX A

AXELROD'S COST AND BENEFIT TABLES

Table 4-1 Examples of Costs and Benefits Segregated by Resource Group

Cost and Benefit Categories	Resources	Examples	Nature
Tangible, direct	Equipment	Processors, peripherals, terminals	Purchase, lease, rental, use charges, maintenance, installation, insurance, legal, taxes
	Software	Operating systems, systems software, applications packages	Permanent license, periodic license, use charges, maintenance, installation, legal, taxes
	Supplies	Tapes, disks, forms, ribbons	Purchase, rental, taxes
	Staff	Internal, external (consultants, agency), part-time	Salaries, benefits, hiring fees, hourly rates, daily rates, fixed fee, taxes
	Space	Offices, plants, warehourses	Purchase, lease, rental, maintenance, insurance, legal, taxes
		Electricity, gas, oil, water	Use charge, fixed charge per period, charge per square foot, taxes
		Cleaning, security, mail, restaurant, linens	Charge per period, charge per square foot, charge per number of employees, taxes
Tangible, indirect	Equipment, software, etc.	Other cost center charges and benefits, general and administrative expenses and benefits	Allocated charges based on square feet, number of personnel, direct expenses, number of departments

[3, p.64]

Table 4-1 Examples of Costs and Benefits Segregated by Resource Group

Cost and Benefit Categories	Resources	Examples	Nature
Intangible, direct	Equipment	Availability, appearance, quality of maintenance, flexibility, longevity, obsolescence, security	Time between failures, time to repair, experience of service personnel, ease of upgrade (field upgradability), modularity of design, planned enhancements, latest technology
	Software	Flexibility, portability, complexity (ease of use), security, quality of support, freedom from error, obsolescence	Modularity of design, programming language popularity, quality of documentation, experience of support personnel, time between failures, time to correct, planned enhancements, latest programming techniques and design approaches
	Staff	Flexibility, adaptability, attitude, appearance, ability to learn	Academic qualifications, amount and type of experience, personal integrity, enthusiasm, creativeness, neatness, punctuality
	Space	Flexibility, location, availability, adaptability	Adequacy of utilities (e.g., power and telephone), closeness to transportation, closeness to qualified personnel pool, type of construction (i.e., single story, multistory, interior pillars, exterior pillars, steel frame, wood frame)
Intangible, indirect	Equipment, software, etc.	Other cost center costs and benefits, general and administrative costs and benefits	As for intangible, direct costs and benefits, plus opportunity costs and benefits, effects of delays, accelerated completion, bankruptcy, honesty, ethics

[3, p.65]

Table 4-2 Cost and Benefit Characteristics by Resource Category

Category	Item	Controllability	Variability	Uncertainty	Transience
Tangible, direct	Equipment, software	High	Moderate	Low (lease) Moderate (purchase)	Ongoing (lease) One-time (purchase) (Benefits—ongoing)
	Supplies	Moderate	High	Moderate	Ongoing
	Personnel (costs/benefits)				
	Management	Low	Low/moderate	Low	Ongoing
	"Worker"	Moderate	Moderate/high	Moderate	Ongoing
	External	High	High	Moderate	Intermittent
	Personnel (hire/fire)	Moderate	High	Moderate	One-time
	Space				
	Lease, Rent	Low	Moderate/high	Low	Ongoing
	Purchase	Low	Low/moderate	Low	One-time (Benefits—ongoing)
Tangible, indirect	Other departments	Low	Low/moderate	Moderate	Ongoing
	Shared items	Low	Low/moderate	High	Ongoing
Intangible, direct	Equipment, software	Low	Moderate	High	Ongoing
	Personnel	Moderate	Moderate	High	Ongoing
	Space	Low	Low	High	Ongoing
Intangible, indirect	Other departments	Low	Moderate	High	Ongoing
	Shared items	Low	Moderate	High	Ongoing

[3, p.70]

Table 4-3 Major Factors Affecting the Variability of Costs and Benefits

Category	Item	Degree of Variability	Major Factors Affecting Variability
Tangible, direct	Equipment		
	Per unit	Moderate	Price/performance due to: 1 New technology 2 Economies of scale 3 Market forces (competition) Method of acquisition
	No. of units	High	Changes in business volume New applications Expansion of current systems New modes of operation (e.g., on-line, database, distributed)
	Software		
	Per unit	Moderate	Price/performance due to: 1 New techniques 2 Market forces (competition) 3 Inflation Method of acquisition
	No. of units	High	No. of units of hardware New applications requirements New modes of operation New features for current systems

[3, p.76]

Table 4-3 Major Factors Affecting the Variability of Costs and Benefits

Category	Item	Degree of Variability	Major Factors Affecting Variability
	Personnel		
	Per unit	Moderate	Inflation Market forces (supply vs. demand) New skills requirements (e.g., database)
	No. and type	High	Growth in activities, especially data communications Changes in business volume, especially relating to computer-oriented activities Increase in automation in organizations Project/product related
	Space		
	Per unit	High	Location of building(s) Market forces (supply vs. demand) Method of acquisition Quality of property, internal amenities, external facilities (transportation, etc.)
	No. of units	Moderate	Equipment and personnel requirements (storage, personal facilities, etc.)
Tangible, indirect	Overhead	Low	Size of organization Type of organization (e.g., business, government, academic) Nature of business, industry (e.g., capital intensive, labor intensive) Age of organizatic Maturity of industry Management style—efficiency, productivity Cost-accounting methods

[3, p.77]

Table 4-3 *(Continued)*

Category	Item	Degree of Variability	Major Factors Affecting Variability
Intangible, direct	Equipment, software, supplies	Moderate	Technological changes Market forces (competition) Relative power of buyer (vs. other buyers and vs. seller) caused by size of buyer, order, etc. Relative power of seller (vs. other sellers and vs. buyer)
	Personnel	Moderate	Market forces (competition) Image of employer (e.g., dynamic, conservative) Work environment, (e.g., pleasant, pressured) Quality of management (e.g., task, person oriented)
	Space	Low	Location Market forces (competition) Quality of building maintenance Architectural characteristics and quality
Intangible, indirect	Overhead	Moderate	Red tape (e.g., degree of bureaucracy, formality) Cooperation (e.g., interdepartmental, team attitude) Attitude toward amenities (e.g., eating facilities, benefit plans)

[3, p.78]

Table 4-6 Various Methods of Analysis and Their Advantages and Disadvantages

Method of Evaluation	Description	Advantages	Disadvantages
Net benefit	Total benefits minus total costs	Easy to calculate Easy to present Easy to interpret	Does not account for different magnitudes of expenditure Does not include the time value of money
Benefit-to-cost ratio	Total benefits divided by total costs	Easy to calculate Relatively easy to interpret	As for net benefit
NPV	Discounted benefits minus discounted costs	Accounts for the time value of money Relatively easy to calculate Can easily compare more than two activities	Relatively difficult to present
RNPV	Discounted benefits divided by discounted costs	As for NPV	As for NPV
IRR	Rate of return required to equate NPV to zero	Accounts for the time value of money Easy to compare IRR to the cost of money Can easily compare two alternatives	Difficult to calculate Relatively difficult to present May not have a single solution, or method may not converge to solution Difficult to compare more than two activities
Payback period	Period required for benefits and costs to be equal	Easy to calculate (for equal periodic proceeds) Provides method for ranking two or more activities Enables comparison between payback period and useful life of investment	Does not (usually) account for the time value of money Does not account for activity cash flows beyond payback period

[3, p.94]

APPENDIX B

HUSSAINS' WEIGHTED SCORE TABLE

Table 6.5 **Worksheet for the weighted-score method**

		Vendor A		Vendor B		Vendor C	
(1) Decision criterion	(2) Weight	(3) Score	(4) Wtd. score	(5) Score	(6) Wtd. score	(7) Score	(8) Wtd. score
Hardware							
Meet needs of growth	3	7	21	7	21	5	15
Throughput/$	5	8	40	6	30	5	25
Communications	2	4	8	8	16	6	12
Real-time capability	1	1	1	5	5	3	3
Storage	2	8	16	6	12	7	14
I/O interface	2	6	12	6	12	6	12
Site restrictions	1	4	4	6	6	8	8
Reliability	3	9	27	6	18	8	24
Ease of use	1	6	6	8	8	6	6
Total for hardware			135		128		119
Software							
Monitors	5	8	40	9	45	4	20
Compilers	4	7	28	9	36	3	12
Multiprogramming	1	8	8	8	8	6	6
Query capability	1	7	7	6	6	5	5
Data management	3	7	21	9	27	4	12
Reliability	3	8	24	9	27	6	18
Packaged software	2	8	16	9	18	5	10
Utility software	2	8	16	9	18	6	12
Documentation	4	7	28	7	28	8	32
Total for software			188		213		127
Other							
Cost	40	4.5	180	3	120	9	360
Engineering support	3	9	27	7	21	3	9
Systems support	4	9	36	6	24	1	4
Education	5	7	35	7	35	5	25
Reputation and stability	2	10	20	7	14	5	10
Delivery date	1	6	6	5	5	9	9
Total for other items			304		219		417
Total for each vendor			627		560		663

[20, p.110]

APPENDIX C

MARTIN'S PAYOFF MATRIX CHECKLIST

PAYOFF MATRIX
(Decision Making Checklist)

1. Develop Alternatives.

2. Determine States of the Future.
   a. What is Planning Horizon?
   b. Which states are more relevant?

3. Determine Payoff Values.
   a. Determine Selection Factors.
   b. Assign relative weights to factors.
   c. For each factor.
      (1) Determine subfactors.
      (2) Allocate factor weight to subfactor according to relative importance.
      (3) For each state of the future, rank alternatives for each subfactor.
      (4) Compute weighted ranking, for each subfactor.
      (5) Sum weighted rankings to arrive at weighted total for each factor.
   d. Sum weighted totals for each factor to arrive at Grand Weighted total which is the payoff value.

4. Solve the Payoff Matrix.

5. Select the Best Alternative.

6. Perform Sensitivity Analysis.

7. Go Back to Steps 2 or 3 as necessary.

[29, p.18]

APPENDIX D

BROCATO'S MASTER LIST

BROCATO'S MASTER LIST [30, pp.52-3]

Hardware

Central Processor

- Instruction set and special features (flexibility and power of the instruction set, availability and fexibility of the decimal instruction set, ease of bit manipulation).
- Addressing (amount of directly addressable core, virtual memory, indirect addressing).
- Double-precision arithmetic functions.
- Availability of storage-to-storage, storage-to-register and register-to-register instructions.
- Fetch time and cycle time.
- Size (words in memory, word size).
- Input/output (channel speed, spooling, number of channels, symbionts such as Hasp, channel overlap).
- Operator dependence (requirements for operator intervention, set-up time).
- Registers (general registers, index registers,floating point registers, several complete sets of registers).

Peripherals

- Direct-access storage (transfer rate, speed of access, maximum storage size, ease of changing storage elements).
- Mass storage (transfer rate, speed of access, maximum storage size).
- Magnetic tape (speed, density, number of units, number of tracks, operator dependence).
- Paper tape (speed, ease of loading, operator dependence, number of tape levels, tape width).
- Card punch (speed, number of stackers, operator dependence).
- Card reader (speed, ease of operation, operator dependence).
- Printer (speed, character set, ease of loading paper, fine adjustments, operator dependence, quality of print, ease of changing character set).
- Communications equipment (speed, number of possible terminals, error rate, error-detection techniques, error-correction techniques).
- CRT terminal (speed, buffer size, remote distance without communications drivers, character set, resolution, number of terminals, ease of operation, quality of display, brightness, color, persistence).
- Optical character reader (speed, ease of operation, operator dependence).

- Magnetic character reader (speed, operator dependence, ease of operation).
- Incremental plotter (on-line speed, off-line speed to generate plotter tape, throughput speed, ease of operation, operator dependence).

Nonstandard Interfaces
- Priority interrupts (hardware servicing, software servicing, speed of service, availability of priority levels).
- Parallel input (number of parallel input terminals, built-in multiplexing, speed of service).
- Parallel output (number of terminals, multiplexing, speed of service).
- Control pulses (availability, decode requirements).
- Clocks (availability, real-time, access by user).

Software

Systems
- Operating system (core requirements, ease of use, accessibility and ease of modification, diagnostic, real-time monitor, batch monitor, time-sharing monitor, input/output support, data protection in event of power failure, allowing time-share users to share programs in core, allowance for altering nuclei, auxilary storage requirements for operating system, size of partition during multiprogramming, data management facilities).
- General support programming (job control language, procedure library, function library, utility programs, assembler, Fortran compiler, Cobol compiler, Algol compiler, various other compilers, linkage editor).

Application Languages
- Assembly language (execution times, ease of programming, ease of debugging).
- Fortran (level, special features, diagnostics).
- Cobol (level, special features, diagnostics).
- Other user-level languages (report generation, sort/merge, Basic, linear programming, simulation, Algol, etc.).
- Real-time (language, interrupt servicing).
- Time-sharing (software servicing).
- Communications (software servicing).
- Compatibility (with existing system, reprogramming requirements, retraining requirements).

Expandability

- Core (availability, addressability, size, ease of modificatiion).
- Mass storage (maximum size, speed, ease of addition, access time).
- Software (ease of modification of software to support hardware expansions).
- CPU

General Support

- Periodic maintenance (frequency, time required).
- Emergency service (hours available, location of service center, availability of service personnel, response time to service request).
- Documentation (clarity, how extensive, availability of manuals).
- Initial training (where given, how extensive, limit on personnel).
- Future training (where given, how extensive, limit on personnel).
- Availability of systems assistance.
- Availability of local backup computer (at least for batch work).
- Availability and vendor support of common user groups.
- Responsiveness of vendor to technical questions concerning the evaluation (both the timeliness and accuracy of the response should be considered here and this should be a fairly high percentage weighted item in the evaluation.

Experience of the Vendor

- Real-time data acquisition.
- Time-sharing.
- Remote batch.
- Local batch.
- Telecommunications.
- Multiprogramming.
- Multiprocessing.
- Simulation.

APPENDIX E

SMITH'S BENEFIT PROFILE CHART

BENEFIT PROFILE CHART

Intangible Benefits of EDP/MIS Leading to Improved Business Performance

Business Function/Activity	Degree of Performance Improvement		
	Some Improvement in Existing System	Significant Improvement in Existing System	Significant New Benefit
Engineering/Research			
Interactive problem solving			
within company			
with customer			
Stimulation of new ideas (e.g., graphics)			
Faster design (e.g., computer-aided design)			
Control of specifications/drawings			
Access to technical information			
Processing of engineering change orders			
Manpower/project management			
Management of professional's time			
(e.g., reduced clerical workload)			
Finance/Accounting			
Budget preparation			
Use of operating/leverage			
Privacy of data/information			
Security of data/information			
Integrity (accuracy of data)			
Planning & control of liquid assets			
Capital budgeting			
Auditing and internal control			
Simplified reporting			
Timely reports			
Employee Relations/Human Resources			
Identification of best performers			
(individual and group)			
Strategic manpower planning			
Places and methods for recruiting			
Improved government reporting			
Monitoring of EEO, ERISA, OSHA standards			
Higher motivation of work force			
career planning capability			
turnover/absenteeism			
fringe benefits planning/control			
job satisfaction			

[37, p.24]

Business Function/Activity	Degree of Performance Improvement		
	Some Improvement in Existing System	Significant Improvement in Existing System	Significant New Benefit
Employee Relations/Human Resources (cont.)			
Employee training			
(e.g., computer-assisted instruction)			
Managerial/professional			
Understanding of how HRM functions			
Labor negotiation capability			
Wage and salary planning/control			
Operations/Production			
Shop floor control			
Production scheduling			
Increase labor productivity			
Pinpoint yield/quality problems faster			
Reduced non-productive time for supervisors			
Measure and report trends			
Accurate labor standards			
General Management			
Increased communication among departments			
Planning data more quickly/easily accessible			
Ability to provide specialized (what if) reports			
Faster development of new systems			
Easier to use system			
Increased secretarial efficiency/effectiveness			
(e.g., word processing/text editing additions)			
Better meetings			
Provides greater reliability (backup)			
Cross referencing of files			
Improved accuracy, conciseness, timeliness, relevance			
of all information			
Cost avoidance (as opposed to performance improvement)			
precludes need to hire new people			
need fewer computer programs (e.g., database)			
need less program maintenance			
reduced communication charges (e.g., distributed sys			
less line charges)			
reduced travel cost (e.g., teleconferencing)			
better use of programmer time (e.g., on-line testing)			
Decision support system			
goal seeking			
what if simulation			
graphics modeling (e.g., visicalc)			

[37, p.25]

APPENDIX F

INTANGIBLE FACTOR PROFILE, WORKSHEET, and EVALUATION

INTANGIBLE FACTOR PROFILE

1. PLANNING PROCESS

   - Level of complexity

2. SITE PREPARATION

   - Possibility of being inadequate

3. CONVERSION

   - Degree of difficulty
     -- Standard languages
     -- Special languages

   - Possibility of being more difficult

   - Possibility of taking more time than planned

   - Possibility of translators not working

4. HARDWARE

   - Technical evaluation

   - Available VS usable resources

   - Expansion potential

   - Compatability with/similarity to old system

5. SOFTWARE

   - Reliability & usability of software packages purchased
     -- Certification of software
     -- Failure rate
     -- Other users' evaluations

- Ease of modifying purchased software for
  - Operating system
  - File management
  - Security
  - Library routines

6. SYSTEMS PERFORMANCE

- Comparison of total times to get job done
- Effort required to optimize

7. RELIABILITY

- Equipment
- Software

8. SECURITY

- Evaluation of security
  - User access
  - File protection
  - Program protection
- Ease of adapting to needs

9. VENDOR SUPPORT

- Vendor ability to meet deadlines
  - Hardware delivery & installation
  - Software modifications
  - Training
- Vendor reputation
- Stability
- History
- Years/degree of expertise
  - Hardware
  - Software
  - Maintenance

- Knowledge of vendor's staff
  - -- Training/teachers
  - -- On-line help
  - -- On-site technical representatives
  - -- Off-site technical representatives

- Easy to get help
  - -- Type of communication (mail form VS "800" line)
  - -- Speed of response

10. EASE OF USE

- Degree of difference from old system
  - -- For operators
  - -- For systems programmers
  - -- For other programmers/analysts
  - -- For end users

- "User friendly" rating
  - -- For operators
  - -- For systems programmers
  - -- For other programmers/analysts
  - -- For end users

11. MAINTENANCE

- Evaluation of diagnostic software

12. SUPPLIES

- Ease of obtaining

13. COMMUNICATIONS/NETWORKING

- Immediate future needs already available

- Speed of transfer

- Impact of proposed networks not working

- Impact of family of computers not compatible

14. FUTURE EXPANSION

- Systems performance VS future growth projections

- Ease of expansion
  -- Physical
  -- Technical

15. DELAYS

- Ability to manage

- Loss of confidence

- Continued leasing of old system

- Extent and possibilities of delays
  -- Hardware late
  -- Software releases late
  -- Vendor not able to fix problem

- Unsuspected complexities in system

- Loss of trained staff (normal rotation, retirement)

16. DOCUMENTATION

- Ease of use
  -- Written to reader's level (end users VS technicians
  -- Similarity to current format
  -- Real examples included

- Available for everything

- Current and accurate
  -- Matches real performance

- Update procedure
  -- How handled
  -- Frequency

- Delivered on time

17. EMPLOYEE MORALE

- Measurement of morale

- Resistance to change

- Evaluation of technology

18. PERSONNEL

- Level of staff expertise with proposed vendor
  - For operators
  - For systems programmers
  - For other programmers/analysts
  - For end users

19. TRAINING

- Quality of vendors training
  - Staff's knowledge/ability
  - Self-teaching aids

- Vendor ability to adapt training
  - Content
  - Schedules
  - Location

20. RISKS

- Needing more equipment than projected

- New or untested technology failing

21. LOST OPPORTUNITIES

- New projects delayed by conversion

INTANGIBLE FACTOR WORKSHEET

__ BENEFIT Major Category ____________

Sub-Category ____________

__ PROBLEM Factor Number ____________

Stage/Milestone ____________

Title: ____________________

____

Brief Description: ____________________

____

____

____

Related to/Dependent on other factors? ____________

____

____

____

Most likely to be:	Chance of occurring	Dollar estimate (if possible)
__ Slight	______	________
__ Average	______	________
__ Above Average	______	________
__ Very Great Impact	______	________

Possible Impact: ____________________

____

____

INTANGIBLE FACTOR EVALUATION

Intangible Factors Major Headings	Importance Value	Adjusted Value	System A		System B	
			Eval. Rating	Weigh. Eval. Rating	Eval. Rating	Weigh. Eval. Rating
1	2	3	4	5	6	7
A. Ease of Use	100	22.73	90	20.46	75	17.05
B. Vendor Support	95	21.59	95	20.51	65	14.03
C. Conversion	95	21.59	98	21.16	80	17.27
D. System Perform.	80	18.18	95	17.27	95	17.27
E. Security	70	15.91	85	13.52	90	14.32
TOTALS	440	100.00	-	92.29	-	79.94

To Create:

- Enter row headings in column 1.
- Column 2 contains the natural, grading type of ratings.
- Sum col. 2 and divide each item in col. 2 by the sum.
- Enter these figures in column 3.
- Rate each system and enter the ratings in column 4 and 6, respectively.
- For each system, multiply value in column 3 times the Evaluation Rating. Divide by 100. Enter result in Weighed Evaluation rating column.
- Example for Ease of Use, System A: (22.73 x 90) / 100 = 20.46
- Sum the Weighed Evaluation Ratings for each system.

Perform Sensitivity Analysis: Experiment with varying the Importance Values to see if the "best" system changes. Also try varying the individual Evaluation Ratings; enter probable extremes and let the spreadsheet readjust the figures.

Note 1: Create this type of format on a spreadsheet. Column 1 shows major headings but the same idea can be used for each one of the major headings to summarize the individual factors.

Note 2: These figures are for illustration only and do not represent true results of any rating.

SELECTED BIBLIOGRAPHY

1. Atwood, Jerry W. The Systems Analyst: How to Design Computer-Based Systems. Rochelle Park: Hayden Book Company, 1977.

2. Axelrod, C. Warren. Computer Effectiveness: Bridging the Management/Technology Gap. Washington, D.C.: Information Resources Press, 1979.

3. ________. Computer Productivity: A Planning Guide for Cost Effective Management. New York: John Wilely & Sons, Inc., 1982.

4. ________. "Costs & Benefits: Specification and Determination." Computerworld 16 (17, 24 May 1982): In-Depth 1-3, 11-6.

5. Bateman, Lynn. "Acquisition." Government Computer News 4 (January 1985): 32.

6. Beeler, Jeffry. "Hardware Planners Told to Try Software Model." Computerworld 15 (September 1981): 22.

7. Blumberg, Donald F. "An Inside Look at the Pricing of Maintenance Services." Data Communications 13 (September 1984): 203-4.

8. Bowles, Marcia Ann. "The Wise Manager's Basic Guide to Conversion." Computerworld 17 (13 June 1983): In-Depth 19-26.

9. Boyle, John Earl. ADPE Acquisition: The Acquisition of the Naval Postgraduate School Computer, A Case Study. National Technical Information Service, AD-A107 478, 1981.

10. Burch, John G., Jr., Felix R. Strater, and Gary Grundnitski. Information Systems: Theory and Practice, 3rd ed. New York: John Wiley & Sons, 1983.

11. Collin, Frank and Tom Moores. "Microprocessors in the Office: A Study of Resistance to Change." Journal of Systems Management 34 (November 1983): 17-21.

12. Dobler, Donald W., Lamar Lee, Jr., and David N. Burt. Purchasing and Materials Management: Text and Cases, 4th ed. New York: McGraw-Hill Book Company, 1984.

13. Donnelly, Tom. "Conferees Settle Sticky Revolving-Door Issue." Air Force Times, 12 August 1985, 14.

14. Federal Conversion Support Center. Review and Analysis of Conversion Cost-Estimating Techniques. GSA/FCSC-81/001.

15. Foss, W. B. "Guidelines for Computer Selection." Journal of Systems Management 27 (March 1976): 36-9.

16. General Accounting Office. Non-Federal Computer Acquisition Practices Provide Useful Information for Streamlining Federal Methods. National Technical Information Service, PB82-120924, 1981.

17. Gilb, Tom. Software Metrics. Cambridge: Winthrop Publishers, Inc., 1977.

18. Giunipero, Larry C., Fred K. Augustine, and Robert A. Henderson. "Purchasing's Role in EDP Acquisitions." Journal of Systems Management 36 (February 1985): 30-5.

19. Goldberg, Robert and Harold Lorin, editors. The Economics of Information Processing, vol. 1. New York: John Wiley & Sons, 1982.

20. Hussain, Donna and K. M. Hussain. Information Resource Management. Homewood: Richard D. Irwin, Inc., 1984.

21. Johnson, Bob. "WHat Counts Most in Product Purchase Decision?" Computerworld 17 (25 April 1983): 1.

22. Khtaian, George A. "Cost/Vendor Evaluation System." Journal of Systems Management 26 (August 1975): 11-9.

23. Kirchner, Jake. "Conversion Can Deter Vendor Lock-In: GAO." Computerworld 14 (30 June 1980): 17.

24. LaRue, S. L. and J. M. DeLorenzo. Comparative Analysis of Government and Private Sector ADP Acquisition. Monteray: Naval Postgraduate School, (NTIS AD-A144523), 1984.

25. Lay, Peter M. W. "Beware of the Cost/Benefit Model for IS Project Evaluation." Journal of Systems Management 36 (June 1985): 30-5.

26. Letmanyi, Helen. "Assessment of Techniques for Evaluating Computer Systems for Federal Agency Procurements." National Bureau of Standards, Pb84-176494, 1984.

27. Levine, Arnold S. "Brooks Act, 20 Years Later, Continues to Have Impact on ADP." Government Computer News 4 (January 1985): 9, 12.

28. Litecky, Charles R. "Intangibles in Cost/Benefit Analysis." Journal of Systems Management 32 (February 1981): 15-7.

29. Martin, Merle P. "Decision Making: The Payoff Matrix." Journal of Systems Management 30 (January 1979): 14-8.

30. McMillan, Benjamin E. "Facing Up to Conversion.", 4 parts. Computerworld 13 (4, 11, 18, & 25 June 1979): In-Depth 13-8, 43-6, 49-56, 51-6.

31. Office of Software Development, Federal Conversion Support Center. Conversion Contracting Techniques Associated with a Replacement ADP Hardware System. GSA/FCSC-81/003.

32. ________. Preparing Software Conversion Studies. GSA/FCSC-81/002.

33. Raymond, Louis. "Decision-Aid for Small Business Computer Selection." Journal of Systems Management 34 (September 1983): 19-21.

34. Robinson, Dexter E. "Buying Information Systems." Journal of Information and Image Management 34 (July 1983): 40-6.

35. Ruth, Stephen R., Dr. "Getting Too Much System - An Avoidable Tragedy." Journal of Systems Management 34 (October 1983): 14-7.

36. Scannell, Tim. "Performance Not Key Buying Point: IDC." Computerworld 16 (23 August 1982): 49.

37. Smith, Robert D. "Measuring the Intangible Benefits of Computer-Based Information Systems." _Journal of Systems Management_ 34 (September 1983): 22-7.

38. Toellner, John. "Project Estimating." _Journal of Systems Management_ 28 (May 1977): 6-9.

39. "Users Underestimate Conversion Costs: Survey." _Computerworld_ 13 (8 October 1979): 55.

40. Vaid-Raizada, Vishist K. "Incorporation of Intangibles in Computer Selection Decisions." _Journal of Systems Management_ 34 (November 1983): 30-6.

41. Vanecek, Michael. "Computer System Acquisition Planning." _Journal of Systems Management_ 35 (May 1984): 8-13.

VITA

Mary Carroll Cobble was born 9 September 1945 in Terre Haute, Indiana. She is the daughter of Mr. Carroll ("Bud") Bruder, deceased, and Mrs. Helen I. Bruder of Terre Haute, Indiana. She is the wife of Major William D. Cobble, USAF, from Stillwater, Oklahoma.

After graduating from Garfield High School in Terre Haute, Indiana, the author attended Indiana State University and received a B.S. in 1967 and a M.S. in 1972, both in Elementary Education with a Math minor. She taught as an elementary teacher for eleven years and as a evening college math instructor for four years.

During the summer of 1980 she attended Officer Training School at Lackland AFB, Texas and was comissioned as a Second Lieutenant in the United States Air Force. She attended Squadron Officers' School at Maxwell AFB, Alabama in 1983. She was an Air Force Institute of Technology student at Trinity University during 1984-1985. She currently is a Captain serving as Chief of the AWACS Software Integration Section at Tinker Air Force Base, Oklahoma.

END

DTIC

9-86