FINAL REPORT

MANAGERIAL COST ACCOUNTING FOR A TECHNICAL INFORMATION CENTER

NASA CONTRACT NSR-15-003-055

Project #12

by

John G. Helmkamp

January 1968

Aerospace Research Applications Center
Indiana University Foundation
Bloomington, Indiana

FOREWORD

by

Joseph DiSalvo

This is the final report for Project #12 of NASA Contract NSR 15-003-055. The style of this report is in a format as required for a Doctor of Business Administration thesis by the Graduate School of Business at Indiana University. The primary purpose of this report, however, is to serve as an operating manual to aid managers of technical information centers in establishment of a sound cost-accounting system.

MANAGERIAL COST ACCOUNTING

FOR A TECHNICAL INFORMATION CENTER

BY

JOHN G. HELMKAMP

A Dissertation Submitted in Partial Fulfillment of
the Requirements for the Degree of Doctor of
Business Administration in the Graduate
School of Business of Indiana University

INDIANA UNIVERSITY
GRADUATE SCHOOL OF BUSINESS

1968

ACCEPTANCE

This dissertation has been accepted in partial fulfillment of the requirements for the Degree of Doctor of Business Administration in the Graduate School of Business of Indiana University.

Date ______________________________

____
Dean, Graduate School of Business

____
Chairman

____
Member

____
Member

PREFACE

I am deeply indebted to many people who contributed so much, either directly or indirectly, to this study. My special thanks go to my Chairman, Dr. Leon Hay, for his multi-dimensional efforts in helping me develop this project and for his constant encouragement throughout my graduate studies. His total contribution to my overall graduate program is immeasurable, and for this I always will be indebted. I also would like to thank Dr. Howard Timms for his valuable insights from the production and quantitative viewpoints and for originally suggesting the topic of this study. I also want to acknowledge the many suggestions and contributions of Mr. Nevin Raber who helped me "bridge the gap" between the disciplines of accounting and information retrieval.

I would like to express my sincere gratitude to the Technology Utilization Division of the National Aeronautics and Space Administration for partial support of this research study under contract NSR-15-003-055. Also, I am particularly indebted to the staff members of the Aerospace Research Applications Center who contributed to the development of the managerial cost accounting system and its application during the test period. Messrs. Harold Shaw, Richard Counts, Max Lipner, Bruce Gobdel, and James Buher deserve my special thanks. Mr. Shaw was quite helpful during the computer programming stage of this study. Also, I am grateful for the efforts of Dr. Arthur Weimer who originally approved the cost accounting application at ARAC and contributed greatly to the final project.

I would like to convey my sincere appreciation to Mrs. Libby Rader and Mrs. Annette Brown for their patience and perseverance in typing the many pages. My special thanks go to Mrs. Rader who sacrificed many hours during the Holiday Season to work on the final draft.

I extend a particular gratitude to my parents who have provided encouragement and assistance over the years. Finally, I am especially indebted to my wife, Sheri, and two sons, John and Kevin, for withstanding the frustrations, moods, and tribulations experienced in our household during this study as well as my graduate education in general. To Sheri, I extend my deepest appreciation for her constant support and encouragement. John and Kevin, who were born during my graduate school tenure, provided a special kind of inspiration and motivation.

J.G.H.

Bloomington, Indiana
January, 1968

TABLE OF CONTENTS

Chapter | Page

Chapter | Page

LIST OF FIGURES

LIST OF EXHIBITS

ABSTRACT

The vast amount of scientific and technical information available in the United States has created a critical need for computerized technical information centers such as those operated in the NASA Regional Dissemination Program. The combination of highly skilled literature specialists and an electronic computer is employed by the centers to search various information sources for two basic services, retrospective search and selective dissemination.

While the operating characteristics of a center are highly analogous to those of a typical business firm, management currently does not possess relevant cost information concerning the literature searching activity. This condition creates a critical problem since the objective of a NASA Regional Dissemination Center is to operate as a self-supporting entity. In order to accomplish the financial objective, relevant cost information is essential for such managerial functions as planning, controlling, performance evaluation, pricing, reporting, and general decision-making.

A two-fold solution to the cost information deficiency problem is proposed in this study. A formal managerial cost accounting system is designed expressly for the two information services of a NASA Regional Dissemination Center, retrospective search and selective dissemination. The system was employed during a trial period at the Aerospace Research Applications Center to test its effectiveness in a technical information center. Once appropriate service cost data are available, the statistical cost model developed in this study can be used in lieu of the formal cost accounting system and will provide an efficient and economical cost control technique.

The managerial cost accounting system consists of a collection of source documents, forms, records, computer programs, computer print-outs, and managerial reports that are designed specifically for a technical information center's operation. Responsibility accounting and service costing are accomplished concurrently since the production costs are charged to the appropriate cost center and information service.

A computerized data processing function is employed to convert cost data recorded during the production process on various source documents into relevant managerial cost information. The appropriate "software" used for the computer capability is an integral part of the managerial cost accounting system. A combination of job order and process costing is employed during the production process and for the electronic data processing function. A job order costing method is used to record the costs consumed for the Retrospective Search Service, but a Selective Dissemination Service contains relatively homogeneous production units so a process costing technique is utilized to calculate weighted-average profile charges for each SDS performance. Development and maintenance costs also are accounted for and are charged to the individual searches.

The statistical cost system is founded on the theory of statistical quality control. Representative values are established on statistical control charts for the direct search cost mean ($\bar{X}$) and the direct search cost range (R). The $\bar{X}$ chart measures the central tendency of the unit search cost data, and the R chart discloses changes in the dispersion of the unit charges. Probabilistic control limits are established to define the acceptable search cost performance in relation to the predetermined targets.

A random sample of five searches is selected every month for both information services, and the direct costs consumed for each sampled search are registered on a single record. The mean and range are calculated for each sample and are recorded on the appropriate cost control chart. The null hypothesis which is tested with the sample information is that the direct unit search costs are "in control" when compared with the representative values. If the sample observations are within the control limits, the hypothesis is accepted, but immediate managerial action is required if a value is recorded outside the desirable limits.

CHAPTER 1

INTRODUCTION TO THE PROBLEM AND PROPOSED SOLUTION

INFORMATION CRISIS

An explosive research and development effort has generated a tremendous growth in science and technology in the United States over the past decade. In 1967, a record $24 billion was forecast—a five per cent increase over the preceding year.[1] A product of this intensive program is an increasing volume and complexity of information available to the scientific and technical community. The determination of a feasible system for disseminating the vast amount of information presents a complex problem. Without such a system, a waste of human resources, time, and money may result from a duplication of research endeavor since prior relevant findings are not available.

Several organizations are contributing toward a solution to the problem by developing information systems. Among the agencies of the federal government concerned are the National Aeronautics and Space Administration (NASA), the Atomic Energy Commission, the Department of Defense, the Science Information Exchange, and the Department of Commerce. The National Science Foundation estimated that the federal government spent $259 million in fiscal year 1966 just to process the reports of past research and development.[2] Similar work is being

---

[1]Victor J. Danilov, "1967 I-R Forecast: $24 Billion for Research," Industrial Research, (January, 1967), p. 32.

[2]Richard L. Lesher and George J. Howick, Background, Guidelines, and Recommendations for Use in Assessing Effective Means of Channeling New Technologies in Promising Directions, Report prepared for the National Commission on Technology, Automation, and Economic Progress (November, 1965), p. 38.

performed by private industrial firms, trade associations, professional societies, and various indexing publications.

Despite these efforts, a lack of systematic organization of the research information still persists. An abundance of information is distributed over a wide range of publications and, as a result, readers find it increasingly difficult to remain well informed. For example, the amount of scientific information published in the world every 24 hours would fill seven complete 24 volume sets of encyclopedias or a total of 61,320 volumes per year.[3] As the store of information becomes more voluminous and specialized, there is a growing requirement for larger collections and better trained subject specialists to more adequately serve the user's needs.[4] Leake summarizes the present status of the information crisis in the following way:

> Something has to give in our current crisis in documentation. Like an overblown balloon, science is ready to burst its conventional bounds. If something does not give, we are going to be drowned in the flood of our scientific knowledge.[5]

NASA REGIONAL DISSEMINATION PROGRAM

General Purpose

The National Aeronautics and Space Act of 1958 charged the National Aeronautics and Space Administration with the responsibility "to provide

---

[3] Ibid.

[4] John Sherrod, "Functions of a Technical Information Center," Information Retrieval Management, ed. Lowell H. Hattery and Edward M. McCormick (Detroit, Michigan: American Data Processing, Inc., 1962), p. 34.

[5] Chauncey D. Leake, "What Must Give in the Documentation Crisis?" Information Retrieval Management, ed. Lowell H. Hattery and Edward M. McCormick (Detroit, Michigan: American Data Processing, Inc., 1962), p. 15.

for the widest practical and appropriate dissemination of information concerning its activities and the results thereof."[6] One of the programs initiated to accomplish this objective and to contribute toward a solution to the overall information crisis was the establishment of several Regional Dissemination Centers.* Nine information centers have been instituted since 1962 in various sections of the United States to disseminate the unclassified results of past research and development to interested parties. The centers, currently operating at varying stages of development, are located at Midwest Research Institute, Indiana University, Wayne State University, University of Pittsburgh, North Carolina Science and Technology Research Center, Southeastern State College, University of New Mexico, University of Southern California, and University of Connecticut. While these centers are not exact replicas, they offer the same type of services and operate under a common set of policies and standards which are administered by the Office of Technology Utilization of NASA.

Man-machine Linkage

The Regional Dissemination Centers are staffed with engineers and scientists who possess diverse educational backgrounds. For example, the staff of the Aerospace Research Applications Center (ARAC) at Indiana University consists of personnel with training in aeronautical engineering, ceramics engineering, chemical engineering, electrical engineering, mechanical engineering, metallurgical engineering, chemistry, geology, life sciences, and physics. For purposes of this dissertation,

---

[6] U. S., Statutes at Large, LXXII, Part 1, p. 427.

*The term "NASA Center" is used as a synonym for NASA Regional Dissemination Center in this study.

the term "engineer" is used to refer to an engineer or scientist who is a literature searcher in a NASA Center. The engineers are information specialists, capable of understanding the information needs of the clientele of the center. A substantial amount of technical training is necessary to properly evaluate the complex literature. With a thorough understanding of the literature, the engineers can search efficiently for information relevant to a user's technical problems and interests.

The other major factor in the operation of a Regional Dissemination Center is an electronic computer. All of the centers have access to computerized information searching, either at their own location or from one of the other NASA Centers. With its vast memory capacity and high speed retrieval capability, the computer provides better search service to the clientele than that attained from a manual effort. The computer system uses a complex of information retrieval programs to search simultaneously for information that is relevant to several requests. Perry and Kent suggest that computerized information centers have made it possible to undertake literature searches which previously required so much time and personal effort that they seldom could be justified.[7]

Information Services

The NASA Regional Dissemination Centers primarily are concerned with information management which, as used in the context of this study, is the management of the receipt, storage, retrieval, reproduction,

---

[7]James W. Perry and Allen Kent, Tools for Machine Literature Searching (New York: Interscience Publishers, Inc., 1958), p. 50.

dissemination, and inventory control of scientific and technical information. A number of other necessary functions are provided by external sources at no cost to the centers. Among these are the original research, processing, indexing, and abstracting.

The services of the centers can be grouped into two broad categories: current awareness and retrospective search. A current awareness service aids a user in keeping abreast of information as it is generated. The clientele are informed regularly of relevant developments in their specialized fields through information searches performed at a center so that their own investigation of books, periodicals, and reports is minimized. Specific interest areas are established, and the current information germane to each topic is identified for the clientele. An example is the Aerospace Research Application Center's Selective Dissemination Service (SDS). Interest profiles, which represent the continuing interest of a user or a group of users are developed in the form of terms that match the descriptors utilized to categorize information in the NASA technical information file. A computer tape containing entries of the latest information in the NASA file is made available periodically to the center so that the interest profile terms can be matched by computer against the descriptors on the tape. The service provides the user with a means of continuous updating in his interest area.[8]

Retrospective searches are designed to aid a user in investigating previous research that has been performed in a given area. The user of the information can execute an exhaustive historical search for

---

[8]Richard L. Lesher and George J. Howick, op. cit., p. 121.

literature pertaining to a well-defined problem by submitting the topic to the center. An engineer develops a computerized or manual search strategy, and the information sources available to the center are searched for relevant documents. The information sources include literary work that originates in a wide range of publications over a period of several years. For example, Weimer describes the information available for retrospective searches at ARAC in the following way:

> Computerized information sources include various research papers and scientific reports that are available through NASA's Scientific and Technical Information Facility which are indexed and abstracted in Scientific and Technical Aerospace Reports (STAR) as well as articles published in more than 600 worldwide technical journals which are abstracted in International Aerospace Abstracts (IAA). Some 150,000 documents are involved and additions are currently being made at a rate approaching 1000 a week.
>
> The Center also has access to materials published by the Atomic Energy Commission and through arrangements with the Department of Commerce, to a substantial portion of the unclassified documents of the Department of Defense.[9]

STATEMENT OF THE PROBLEM

Current Status of Cost Information

The management function of a NASA Regional Dissemination Center is analogous to that of a typical manufacturing concern. Managerial cost accounting represents the major quantitative information system in the

---

[9]Arthur M. Weimer, The Programs of the Aerospace Research Applications Center, Excerpts from a speech presented at the CIC Conference on "The Flow of Innovation and the Management of Research" at Wingspread, Wisconsin, October 26, 1965, p. 3.

latter type of operation as it provides essential data for planning, controlling, and decision-making purposes. One does not have to ponder long to imagine the utter chaos that would exist if the management of a production firm were to find itself without the benefits of cost accounting information. The effectiveness of such managerial functions as pricing, inventory evaluation, cost-profit-volume analysis, budgeting, operational effectiveness evaluation, and cost control undoubtedly would be restricted. However, a deficiency of relevant cost information appears to exist in the operation of most NASA Centers, and the management process is dominated by qualitative factors. In numerous cases, reliance on cost estimates, based on experience and judgment, has characterized management practice in technical information centers.[10]

The dependence on cost estimation appears to stem from the lack of theoretically sound cost accounting applications in the information retrieval field in general. Most libraries are a segment of a larger organization such as a government or corporation, and their operating costs normally are considered as overhead expenses of the parent operation, with little effort exerted to calculate itemized service costs.[11] Instead, the emphasis is on the amount budgeted for various cost classifications such as salaries, equipment, documents, supplies, and travel. Although the costs are incurred so that various information

---

[10] This statement is based on the results of the author's literature review presented in Chapter 2 and an analysis of the research questionnaire disclosed in Exhibit II.

[11] Bernard K. Dennis, "Financing a Technical Information Center," Information Retrieval Management, ed. Lowell H. Hattery and Edward M. McCormick (Detroit, Michigan: American Data Processing, Inc., 1962), p. 69.

services can be performed, the lack of a cost accounting system prohibits a reliable association of the costs and services. McCormick hypothesizes that this problem stems from the fact that, "Conventional information activities normally do not sell their product, hence, are not in a position to be as cost conscious as they might otherwise be."[12] The term "library" is used in this study to refer to all information retrieval operations except technical information centers. Examples are public libraries, university libraries and business firm libraries.

However, the NASA Regional Dissemination Centers are in operation to sell their services to various clientele, and their objective is to be completely self-supporting from service revenue after an initial subsidy from NASA. This goal implies that accurate information is available concerning service costs so that a corresponding price schedule will generate a breakeven level of revenues. Dennis summarizes the policy of the Technical Information Center of General Electric's Flight Propulsion Division by stating that, "The Technical Information Center must act to a certain extent as a business entity, complete with continuing problems of customer satisfaction, sales volume, and seeking out new markets."[13]

Fixed Cost Factor

The operating conditions of a NASA Center complicate the determination of itemized service costs due to the large proportion of fixed

---

[12] Edward M. McCormick, "The Management Process and Science Information Systems," Information Retrieval Management, ed. Lowell H. Hattery and Edward M. McCormick (Detroit, Michigan: American Data Processing, Inc., 1962), p. 135.

[13] Bernard K. Dennis, op. cit., p. 68.

costs incurred by a typical center. Most manufacturing concerns employ a sizable labor element which is classified as a variable cost since it changes proportionately with the operation's volume of activity. Also, raw material costs, which are variable expenses, usually constitute a large percentage of total product costs. However, most of the operating costs of a NASA Center are relatively fixed since they do not vary with volume. The very nature of the work force is the major cause of the phenomenon since skilled engineers and scientists are not the type of personnel that can be hired and discharged or laid off as the activity level changes. Instead, long lead times usually are required to employ the individuals with the desired special training. This, together with the fact that they are generally in short supply, requires offering them stable employment in order to acquire them at all. For purposes of this study, the assumption is made that the information centers must contend with the fixed labor factor for an annual period only. Thus management cannot vary the staff level significantly once an annual operating cycle is in process.

Another operational feature that contributes toward the high percentage of fixed costs is the need for specialized equipment. Reproduction machinery and computer equipment are necessary and, if purchased, produce fixed costs through depreciation charges. Leasing arrangements, if available, often include a fixed usage guarantee. Also, the lack of raw materials in the information production process contributes substantially toward the sizable fixed costs. The final product, a deck of relevant information abstracts, is the result of information searching and processing, so the majority of the total costs is labor expenses. Only a minimum quantity of miscellaneous supplies is used in the production flow. Therefore, the critical problem is one of determining a feasible cost system with which to allocate objectively the fixed costs that often are common to several services and to distribute the relatively small portion of variable costs. Most cost accounting information admittedly represents approximate measurements rather than precise facts.[14] This condition is especially true when an extensive allocation of joint costs is necessary, which is the case in the operation of a NASA Center with its large proportion of fixed costs. Nevertheless, a cost system based on a set of theoretically sound decision rules should produce information that is consistent and defendable as being objectively determined. Such a system should generate a scientifically determined service cost structure.

Potential Management Applications

A wide range of managerial applications appear most likely if reliable cost and related operational information is available. The following list illustrates some management techniques, dependent on accurate cost accounting information, that should contribute toward an efficient information center operation:

1. Performance evaluation

   Responsibility is given to various staff members to accomplish certain objectives within given time and monetary constraints. Realistic physical quantities and related costs are determined for the expected production volume, and the employees responsible for the various work activities also are accountable for the

---

[14] Robert N. Anthony, Management Accounting (3rd ed.; Homewood, Illinois: Richard D. Irwin, Inc., 1964), p. 7.

controllable costs of their operations. Periodic performance reports are generated from the managerial cost accounting system to evaluate how effectively the targets are achieved.

2. Planning the operation

Planning is the process of determining what action should be taken in the future. This activity must be performed at all levels of the organization since it establishes the operational targets that reflect management objectives. Projected work activity, manpower needs, space requirements, equipment expenditures, and available funds all are considered in the planning process. An example is the budget which represents a plan showing how the the resources needed for a given period will be acquired and utilized. Consumer demand for the information services is forecast, and the resources required in the various departments of a NASA Center are budgeted as realistic estimates of what can be expected during the period.

3. Controlling the operation

Control is the process through which management insures that actual operational activities conform favorably with the targets established in the planning function. Reports indicate any deviations from the targets so that materially unfavorable variances can be investigated and appropriate corrective active can be taken. Managerial cost accounting information is necessary to establish realistic targets and to measure the actual performance.

4. Managerial Decision-making

Management of a NASA Center often is required to make decisions by choosing between several alternative courses of action. When relevant managerial cost accounting data are available, the decision can be reduced to a quantitative basis, and a considerable amount of subjectivity is eliminated from the process. Since the objective of a NASA Center is to operate as a self-supporting, breakeven organization, alternative courses of action should be evaluated in quantitative terms, whenever possible, to insure that the relevant economic factors are considered. Examples of such decisions are: (1) Equipment purchases; (2) Capacity expansion; (3) Information service feasibility analysis; (4) Service pricing, and (5) Make-buy decisions concerning documents.

5. Pricing the services

Since the objective of a NASA Regional Dissemination Center is to operate at a break-even revenue level, service cost information should be available to serve as the basis of the prices charged to clientele. All operating costs of a center must be distributed objectively to the information services if this full-cost pricing basis is to be determined. A managerial cost accounting system is necessary to employ effective decision rules for the calculation of the cost of producing and distributing the information services.

6. Reporting to various internal and external sources

Internal reporting will be a regular occurrence to insure that the appropriate management information is available at the right time. Such reports should represent an accurate description of a center's operating performance during a given period. Also, external parties such as sponsoring agencies, universities, and clientele may have an interest in the operation and require similar reports of the financial performance of a center.

MANAGERIAL COST ACCOUNTING SYSTEM

General Scope

The first major objective of this study is the development of a computerized managerial cost accounting system that the author proposes is appropriate for the NASA Regional Dissemination Centers. The system is designed to account for the costs of the two basic types of service, current awareness and retrospective search. Although the various NASA Centers may offer slightly different services, they should be able to classify any given service as one of the two types and use the related cost accounting philosophy. Since all of the centers operate under a common set of policies and standards, any service variations should be minor.

The system is based on elements from the following: (1) generally accepted accounting theory; (2) a review of the relevant literature from such disciplines as accounting, library science, management science, and information retrieval; (3) information collected on a research questionnaire that was distributed to the managers of the various Regional Dissemination Centers. A glossary is presented in Exhibit I to define the major cost terminology used in this study. The components of the system—ranging from source documents such as work orders, time tickets, and computer printouts to reports such as income statements, labor performance reports, and service cost reports—are designed specifically for an information center. An electronic computer performs the major data processing operations required in the managerial cost accounting system. Three computer programs provide the necessary operating instructions and are presented in the Appendicies.

The overall costing technique employed in the system is a combination of job order and process costing methods. A current awareness service such as ARAC's Selective Dissemination Service requires a production process that generates relatively homogeneous products. As an engineer periodically services the interest profiles, he may spend only a few minutes on each one so it would not be feasible to attempt to measure finitely the exact amount of time expended on each profile. Also, the output of several profiles may be interrelated, and the engineer may work on the corresponding units concurrently. Yet, information concerning the cost of servicing the individual profiles is necessary to calculate the unit SDS costs. Such information is acquired in the system by a process costing technique through which all costs consumed during a specific time period in a given cost center are collected but are not related to individual units of output. A weighted-average distribution process generates unit cost data as the total SDS production performance costs are divided by the service output. A specific decision rule is developed in Chapter 5 to determine the proper numerator and denominator of the averaging method.

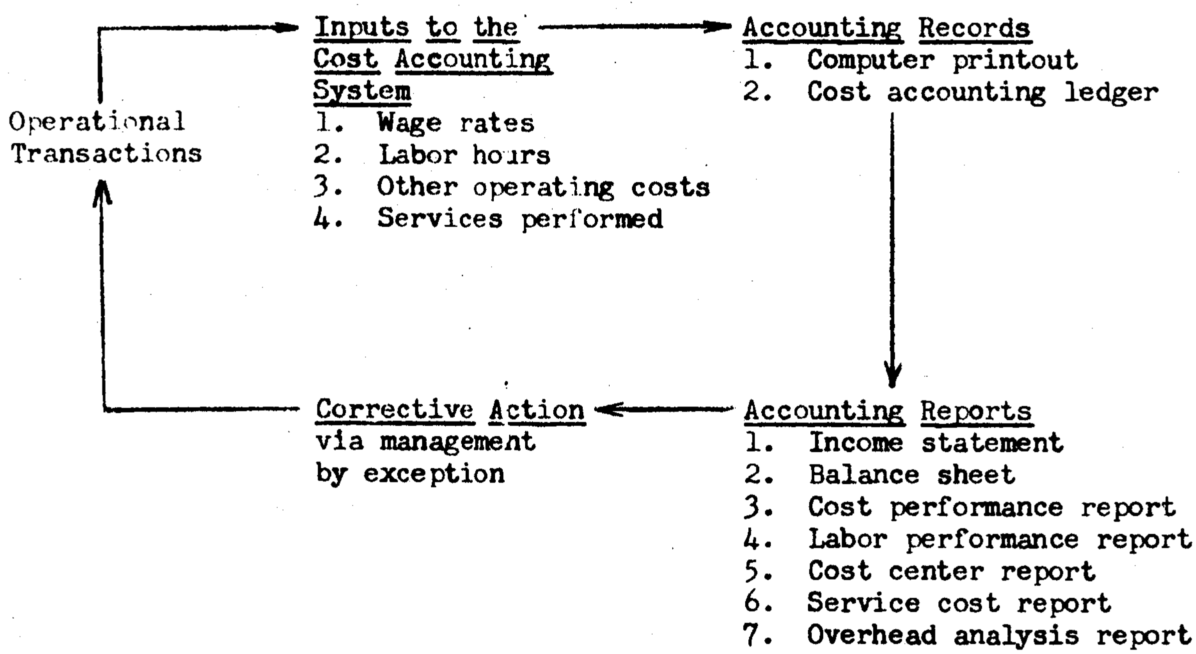
Each retrospective search represents a unique job that is accounted for as a heterogeneous unit. Every search is identifiable as a specific job passing through the production process and requires larger work increments than those employed for the interest profiles. For example, the production process consists of an engineer accomplishing several functions such as problem evaluation, search strategy preparation, designation of the computer terms which define the problem, and the edit of the computer printout that shows the identified references. A job order costing technique is used to record these labor costs as the search is performed, and all other related expenses are charged to the project.

Managerial Accounting Concepts

A managerial cost accounting framework is employed as a closed-loop control system that is illustrated in Figure 1-1. Responsibility accounting is utilized to appraise the performance of the controllable costs consumed in cost centers established throughout the organization. The manager responsible for the work activity of each cost center also is accountable for the controllable costs of the operation. Budgeted cost figures are selected as targets, and regular performance reports indicate the relationship of the actual and budgeted costs. Corrective action is initiated for unfavorable variances through management by exception to complete the closed-loop objective.

Figure 1-1

Managerial Cost Accounting Process



Several cost classifications such as variable versus fixed, direct versus indirect, controllable versus noncontrollable, and service versus nonservice are essential for the managerial accounting process. The numerous cost groupings can be determined from the output of the single system and each has distinct advantages, depending on the reason the data are requested. For example, due to the sizable fixed cost element, conventional applications of the variable-fixed dichotomy are of minimal importance. A more significant classification is direct versus indirect since many of the fixed as well as the variable costs can be traced to the services and classified as direct charges for costing purposes. If a flexible budget is employed to establish a predetermined rate for the application of the indirect operating expenses, unit service costs can be calculated, based on a system that adjusts for periodic changes in activity. A substantial amount of indirect labor will exist whenever the service volume varies below the established production capacity because the relatively fixed work force cannot be adjusted during the operating year. Since the staff level cannot be varied proportionately with the information searching activity, unproductive time must be accounted for as indirect labor. Therefore, whenever the production volume is less than that forecast for the determination of the work force level, a large amount of indirect labor costs is incurred. This deviation is identified as an unfavorable variance in an overhead analysis report which aids management in achieving more efficient manpower levels in future operating periods. Without the stabilizing overhead application procedure, the large portion of fixed costs would cause fluctuating unit service costs as a constant amount would be distributed over various activity levels.

Cost-volume comparisons are investigated critically, and the relationship between marginal and average costs is examined to support the use of average costs for pricing the information services. Once again, the large proportion of fixed costs complicates the pricing problem since volume changes will affect unit costs if the fixed costs are distributed over different levels of activity. However, as suggested earlier, one of the features of the cost system is a flexible budget for the indirect operating expenses that will tend to level what would otherwise be erratic average unit costs. The budget should relate to a time period which is lengthy enough that the irregular costs and activities tend to balance out.

The predetermined overhead rate established in the flexible budget is applied to some activity basis such as direct labor hours to include a share of the indirect charges in the unit service cost. Thus, unit service costs are computed on the basis of normal production activity rather than the actual level. Horngren summarizes the advantages of this procedure in the following manner:

> Such an approach has a logical foundation because a normal product cost is more meaningful and representative for inventory purposes than a so-called "actual" product cost that is distorted by month-to-month fluctuations in production volume and by erratic or seasonal behavior of many overhead costs.[15]

Verification of Results

A one way, fixed effects analysis of variance model is introduced in Chapter 3 to test the consistency of the mean service costs over different time periods. An analysis of variance model represents a statistical technique which can be utilized to measure differences between two or more sample means. Hoel explains the use of such a model in the following way:

> One of the most useful techniques for increasing the sensitivity of an experiment is designing it in such a way that the total variation of the variable being studied can be separated into components that are of experimental interest or importance. Splitting up the total variation in this manner enables the experimenter to utilize statistical methods to eliminate the effects of certain interfering variables and thus to increase the sensitivity of his experiment. The analysis of variance is a technique for carrying out the analysis of an experiment designed from this point of view.[16]

---

[15] Charles T. Horngren, Cost Accounting - A Managerial Emphasis (2nd ed.; Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1967), p. 84.

[16] Paul G. Hoel, Introduction to Mathematical Statistics (3rd ed.; New York: John Wiley and Sons, Inc., 1962), p. 299.

In Chapter 2, numerous intervening variables which influence the unit cost of an information search are identified. Several of the more important factors are:

1. The complexity and structure of the information requests (for purposes of this dissertation, complexity refers to a subjective estimate of how difficult a given information request is to satisfy).

2. The number of relevant information abstracts discovered during the search process.

3. The amount of potentially relevant information available for searching.

4. The familiarity and knowledge of the literature searcher concerning a specific request.

5. The number of information searches performed per computer run.

The effect of the intervening variables is a wide dispersion of unit search costs as particular combinations of the factors contribute to specific charges. For purposes of this study, the assumption is made that the distribution of the multi-dimensional factors affecting individual searches remains relatively constant between monthly periods during a short duration when all searches of a given service are considered. For example, if 50 searches are performed during January, the distribution of the multi-dimensional, intervening variables will be approximately equal to that of the factors related to 48 searches executed during February. Since the retrospective searches normally arrive randomly and approximately the same SDS interest profiles are serviced every month, the assumption of the "averaging out" of the intervening variables per unit between periods appears realistic. Consequently, if the cost accounting system is operating effectively and the distribution of the intervening variables remains relatively constant, the average unit cost of a given service should be approximately the same from period to period, subject only to random error. Literature searching efficiency improvements may cause lower unit search costs over an extensive duration, but their effect is unlikely to be significant in the short run. The analysis of variance model can be used to test the hypothesis that the mean unit costs are approximately equal with an "F" distribution of the ratio of the mean square between columns and the mean square within columns. If this ratio is not significantly greater than one, the hypothesis is accepted as being true. If the hypothesis is rejected, further investigation is warranted to determine the exact nature of the variation.

Summary

The first objective of this study is the development of a managerial cost accounting system that is applicable to a NASA Regional Dissemination Center's operation. Information service costing is performed within a managerial accounting framework, and the resulting cost data should be relevant for planning, controlling, and decision-making purposes. The direct costs are traced to specific services during the production process, and the indirect charges are applied on the basis of a predetermined overhead rate. Cost performance is evaluated throughout a center's operation by the responsibility accounting process, and the average service costs provide a realistic basis for a pricing policy. An analysis of variance model is employed to examine the average costs for consistency, thus testing the proposal that they are representative costs of the service production processes.

STATISTICAL COST CONTROL

Basic Concepts

The second major objective of this study is the development of a statistical cost control model that can be used, if management prefers, after reliable unit service costs are established. Statistical cost control, based on probability sampling theory, also provides valuable managerial information although it will not be as exhaustive as that generated by a complete cost accounting system. However, considerably less contribution from the operating personnel is required in the statistical model since the foundation of any formal cost accounting system is a detailed reporting process concerning the consumption of labor, materials, and overhead for every product. Source documents such as labor time tickets, supplies requisitions, and work orders must be completed for each cost transaction performed during the production process. Such detailed accounting requires a substantial amount of time and effort on the part of the operating personnel. The use of the statistical model minimizes the reporting function since a relatively small number of service units are sampled for cost control purposes.

Most business firms employing formal cost accounting systems exercise rigid control checks to insure that the information reported by the employees is accurate. However, the majority of the personnel concerned with the completion of the source documents are "blue collar workers" who are accustomed to such routinism.[17] Cummings says that,

---

[17]Ely Chinoy, "The Tradition of Opportunity and the Aspiration of Automobile Workers," The American Journal of Sociology, LVIII (March, 1952), p. 453.

"Unskilled, semiskilled, and even some managerial incumbents are 'taught' the proper procedures and rules which sustain the character or personality of that particular organization."[18] However, in a technical information center, most of the operating personnel are highly educated engineers whose training and work demands a great deal of independence if they are to search the relevant literature efficiently.

Hamberg hypothesizes that independence is a dominant trait among creative scientists. He defines independence as the desire to follow one's own interests without direction or interference from management controls.[19] A study conducted by LaPorte to examine the sources of strain that affect research scientists revealed that one of the two main conflicts is the perceived restrictiveness of administrative procedures. Such measures as equipment control and budget allocations are major sources of irratation since the scientists believe the measures unduly constrain their activities.[20] Another study by Friedlander and Walton disclosed that one of the primary reasons government scientists remain for extensive periods on the same job is technical freedom from administrative control.[21]

---

[18] Larry Cummings, "Organizational Climates for Creativity," Journal of the Academy of Management, VIII (September, 1965), p. 225.

[19] Daniel Hamberg, Essays on the Economics of Research and Development (New York: Random House, 1966), p. 100.

[20] Todd R. LaPorte, "Conditions of Strain and Accomodation in Industrial Research Organizations," Administrative Science Quarterly, X (June, 1965), p. 27.

[21] Frank Friedlander and Eugene Walton, "Positive and Negative Motivations Toward Work," Administrative Science Quarterly, IX (September, 1964), p. 202.

Consequently, it is hypothesized that a burdensome organizational effort and/or possible behavior problems may limit the usefulness of a formal cost accounting system if it is used for an extensive period. However, if the personnel are convinced, by the managers responsible for the installation of the system, of the overall benefits to the center from reliable cost and operational information, it is proposed that they will be willing to contribute dependably for a short time period. The cost data should provide useful information for them as they periodically interact with the clientele since the users are charged for the services on the basis of actual costs.

Sampling Theory

If the management of a technical information center judges that a sustained utilization of the formal cost accounting system is unrealistic due to these or other reasons, it may choose to switch to statistical cost control after dependable cost targets have been established. The analysis of variance model will provide an objective test with which to determine the reliability of the mean costs.

Once the cost data are determined to be valid, representative parameters can be calculated for a statistical cost control model. A random sample of service units is selected each month, and the statistical parameters are computed to insure that the cost targets are being achieved. Vance and Neter list the following advantages of using sampling methods rather than considering the entire population of data:

1. Timeliness
   The results from sampling usually are available faster than those pertaining to the entire universe due to the required computational time.

2. Economy
   Less human effort is required to record the costs, and less processing time is necessary since fewer products are considered.

3. Accuracy
   Since the personnel realize that they do not have to record and collect a complete set of information, they should be more accurate when handling those items included in the sample.

4. More detailed analysis
   More time is available for the responsible personnel to interpret and report the data than if they were concerned with the additional computational effort of the entire universe.[22]

Relevant Costs

The direct service costs of the sampled information searches are recorded on a single cost record as each unit progresses through the production process. Direct costs are such items as the labor, computer time, telephone calls, and reproduction supplies that are identified readily for a given service. Indirect costs are excluded from the model since they are distributed to the services in a formal cost accounting system by a predetermined rate that is applied to some activity basis such as direct labor costs, direct labor hours, or units produced. A simplifying assumption is made in the statistical cost system that the actual indirect costs are absorbed completely, and the total search costs are considered as a linear combination which is dependent only on the

---

[22] L. L. Vance and J. Neter, Statistical Sampling For Auditors and Accountants (New York: John Wiley and Sons, Inc., 1956), p. 12.

random variable—direct costs. Since the purpose of the model is to determine whether or not the information production process is "in control" in relation to predetermined cost targets, this assumption appears reasonable.

Statistical Cost Control Charts

The sample results are recorded on two statistical cost control charts that distinguish between random deviation and significant variances which require investigation. The statistical cost model requires a minimum amount of work since corrective action is not necessary as long as the sample parameters are within the allowable variation from the cost targets. If the sample results are outside the control limits, corrective action should be initiated to determine the cause since it is unlikely that the situation is produced by random error.

The two parameters of interest in the statistical cost control model are $\bar{X}$, the average unit search cost, and R, the range of unit search costs. The former statistic is utilized as a measure of the central tendency of the production cost data, and the latter is employed to discover changes in the dispersion of the unit costs. Representative amounts for both parameters are established as the targets of the two control charts, and the characteristics of a normal probability distribution are used to set the upper and lower control limits which define the acceptable cost results. For example, given a distribution of measurements that is approximately bell-shaped, the mean of the distribution plus and minus one, two, and three standard deviations contains approximately 68%, 95%, and 99.7% of the measurements, respectively.[23] As long

[23] Paul G. Hoel, op. cit., p. 101.

as the sample observations behave in accordance with the probability limits, the search cost process is "in control." Trueblood and Cyert explain the use of a statistical control model in the following way:

> The theory of the control chart is based on the behavior of the sample means. As long as the universe can be reasonably approximated by a normal distribution, it can be safely assumed that the distribution of arithmetic means will be normally distributed. Even when the universe is abnormal, the distribution of sample means will usually approach a normal distribution if the sample is sufficiently large.[24]

Thus, probability sampling techniques are employed monthly to estimate the unit direct costs of the information production process. Representative values of the average unit search cost ($\bar{X}$) and the dispersion of the unit costs (R) are established as targets on two control charts prior to the initial sampling procedure. The values of $\bar{X}$ and R are calculated for each monthly sample and plotted on the control charts to determine the extent of any deviation from the targets. If a value is outside the acceptable control limits, management action is necessary to determine the cause of the material deviation. Otherwise, the null hypothesis that the cost process is "in control" is accepted. The model provides an efficient cost control technique with a minimum contribution from the center personnel.

SUMMARY OF SURVEY RESULTS

A research questionnaire was distributed to the directors of the nine NASA Regional Dissemination Centers to investigate their opinions

---

[24]Robert M. Trueblood and Richard M. Cyert, Sampling Techniques in Accounting (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1957), p. 145.

concerning the current status of cost information in their operations. A personal interview also was conducted by this author to clarify any ambiguous replies recorded on the questionnaires. Seven of the managers responded to the request, and the results are presented in Exhibit II. The three major research objectives of the survey were the following:

1. To analyze the current status of cost accounting practices employed in the NASA Centers.

2. To evaluate whether or not the existing cost accounting capabilities could be improved.

3. To give the managers an opportunity to disclose their opinions of cost accounting concepts that would be beneficial to the operations.

The results of the survey indicate that a definite deficiency of relevant cost information exists in the NASA Centers. Only one center possessed a cost accounting system, and that case represented a project performed earlier by this author for the determination of a feasible fee schedule. The other centers obtained cost information from several sources, ranging from rough estimates to a statistical cost system. Also, only two of the centers attempted to utilize actual costs for the determination of the service prices charged to the clientele.

All of the responding directors reported a willingness to install a formal cost accounting system if it were available, and six of the managers believed that a need existed for improved cost information. Most of the directors felt that relevant cost data would be beneficial for such management functions as planning, controlling, performance evaluation, scheduling, pricing, and decision-making. Numerous suggestions concerning the nature of appropriate cost information and reports also were disclosed and are presented in Exhibit II, Appendix IV.

The research questionnaire results substantiate an inference drawn by this author from a literature review pertaining to the subject of cost accounting applications in information retrieval operations. The details of the literature review are discussed in Chapter 2, but the most essential discovery was the consistent opinion of various authors that relevant cost data are needed but not available in information centers. The directors of the NASA Centers indicated that they recognized the importance of relevant cost information but also disclosed its absence in their present operations.

CHAPTER ORGANIZATION

This study is organized into seven chapters. The present chapter contains a brief description of a NASA Regional Dissemination Center's operation, a definition of the cost information problem, and the conceptual framework upon which a proposed solution is developed. In Chapter 2, a review of past literary work that is potentially relevant to the cost information problem is presented and analyzed.

Chapter 3 contains a detailed description of the basic managerial cost accounting concepts underlying the proposed cost system. In Chapter 4, the mechanics of the managerial cost accounting system are applied to the Retrospective Search Service. Chapter 5 describes the essential features of costing a Selective Dissemination Service.

In Chapter 6, a statistical cost control model is developed. The statistical system can be employed in lieu of formal cost accounting to determine whether or not the information search costs are "in control" when compared with a predetermined target. Chapter 7 contains the summary and conclusions of this study as well as inferences related to the utility of the research in the general area of information retrieval.

CHAPTER 2

LITERATURE REVIEW AND CRITIQUE

INTRODUCTION

The purpose of this chapter is to identify and analyze past literary work that is germane to the design of a cost system for a technical information center. The choice of the relevant publications presents a difficult problem because most of the cost literature in the information retrieval field is concerned specifically with such functions as indexing, documenting, copying, data processing, and reproduction, and usually is based on cost estimation procedures so its contribution to the design of an appropriate cost system is marginal.

The relatively small body of relevant cost literature is probably a function of the fact that library expenditures normally are considered as overhead costs (See the discussion of Chapter 1). Most libraries are funded by an indirect source such as a governmental agency, a trade association, or an industrial firm, and detailed cost information is not mandatory since the customers do not pay for the services. However, with the computerized technical information centers established in the NASA Program, this philosophy is not applicable. Publications which are directed at the topic of cost control for technical information centers as well as libraries in general are reviewed so that any pertinent concepts are considered in the system design of this study.

Instead of attempting to review the voluminous body of accounting literature related to cost systems and their managerial applications, the analysis is limited to that pertaining to the research and development function. The rapid technological advances in most industries have made extensive research and development programs a necessity. The increasing costs of such projects have generated a substantial amount of interest in the determination of suitable cost control techniques. Since a research and development operation is highly analagous to that of a technical information center, a corresponding cost system appears realistic. A comparison of the two functions indicates that both employ technically-oriented personnel, utilize similar operating procedures, and in essence are concerned with the same type of results.

COST LITERATURE - INFORMATION RETRIEVAL

Evidence of Inadequate Cost Information

Kent, who currently is on the staff of The Knowledge Availability Systems Center, surveyed the managers of several specialized information centers to investigate the status of cost data available for the various information activities.[1] The results show that a lack of actual cost information definitely existed at the centers. Kent presents a summary of the opinions of the managers regarding cost factors in information retrieval but admits that the views may be biased due to the inadequate cost information. Nevertheless, the study discloses the managers' experience with such elements as the cost of input materials, systems costs, and the determination of a fee schedule. However, the emphasis on cost estimation rather than cost measurement appears to have created a wide range of opinions and practices.

---

[1]Allen Kent, _Specialized Information Centers_ (Washington, D. C.: Spartan Books, 1965), p. 264.

McCormick, a member of the National Science Foundation staff, asserts that the precedent for the operation of a technical information center is the traditional library function which normally is a part of the overhead costs of a sponsoring organization.[2] However, the revenue-generating objective of a computerized technical information center nullifies this philosophy and creates a need for management information. The author summarizes the problem in the following way:

> In order to close the management control loop, it is necessary to collect and organize information about the operating system that will permit further evaluation, modification of goals, and revision of the system if necessary. Again the problem is familiar to management. Further, the need for obtaining valid cost information is obvious.[3]

McCormick hypothesizes that one of the critical problems underlying the current status of cost control in a technical information center is that, in most cases, many of the costs are hidden. For example, the costs of the information retrieval function and the original research projects may be combined so it is difficult to determine realistic costs for the operation of a center. In order to solve this problem, records should be kept separately for the various functions.

An example of a cost study of an information center in which the author included such input costs as those of the original research project and the documentation expenses was that performed by Mueller at the Operations Research Division of the Lockheed Aircraft Corporation.[4]

---

[2]Edward McCormick, "The Management Process and Science Information Systems," Information Retrieval Management, ed. Lowell H. Hattery and Edward M. McCormick (Detroit, Michigan: American Data Processing, Inc., 1962), p. 135.

[3]Ibid.

[4]Max W. Mueller, "Time, Cost, and Value Factors in Information Retrieval," General Information Manual: Information Retrieval Systems Conference September 21-23, 1959, Poughkeepsie (White Plains, New York: International Business Machines, 1960), p. 12.

In assessing the value of Mueller's study, Newman suggests that the inclusion of the input cost items only obscures the normal operating costs of an information center since they will be incurred regardless of how the resulting information is utilized.[5]

Peters states that, "Technical information centers need the same kind of cost control that industrial plants and research laboratories have found essential in their operation."[6] He suggests that the lack of cost data in the information retrieval field is a result of the fact that the centers only recently have been organized as independent units that sell their services since library costs traditionally have been treated as overhead items.

Langenbeck hypothesizes that library operating costs will continue to increase as the volume of scientific literature grows.[7] He believes that the critical problem concerning library cost control stems from the past practice of analyzing feasible information retrieval methods without adequate cost analysis techniques. He concludes that if the increasing volume of engineering and scientific material is to be handled economically, more efficient systems will have to be discovered or the handling costs will be prohibitive. However, if an objective analysis

---

[5]Simon M. Newman, "Economic Justification - Factors Establishing System Costs," Information Retrieval Management, ed. Lowell H. Hattery and Edward D. McCormick (Detroit, Michigan: American Data Processing, Inc., 1962), p. 118.

[6]Alex Peters, "Cost Accounting/Allocation," Technical Information Center Administration, ed. Arthur W. Elias (Washington, D. C.: Spartan Books, Inc., 1964), p. 104.

[7]Earl H. Langenbeck, "A Plan to Reduce Costs of Technical Library Operations in the Department of Defense," American Documentation, XIII (July, 1962), p. 295.

of the various systems is to be accomplished, accurate cost data will be mandatory.

Berul, in a research project performed for the Auerbach Corporation, states that, "Very few information centers have adequate cost accounting systems and, as a result, there is not much data available on the cost of information center operations."[8] Perry and Kent also assert that information center expenses usually are treated as an overhead item since present accounting methods are not applicable for such an operation.[9]

Overmyer, a staff member at the Center for Documentation and Communication Research of Western Reserve University, suggests that, "Despite its apparent importance, there has been very little written in the field of information retrieval which will answer the question, 'How much does it cost?'"[10] He concludes that the probable reason for this is that very few centers have cost accounting systems so there is nothing to report.

Cost Control Applications

Dennis discusses the problems connected with the financing of a technical information center operated by General Electric Company.[11] He

---

[8]Lawrence Berul, Information Storage and Retrieval - A State of the Art Report (Philadelphia, Penn.: Auerbach Corporation, 1964), p. 7-1.

[9]James W. Perry and Allen Kent, Tools for Machine Literature Searching (New York: Interscience Publishers, Inc., 1958), p. 49.

[10]LaVahn Overmyer, "The Dollars and Cents of Basic Operations in Information Retrieval," Information Retrieval in Action (Cleveland, Ohio: The Press of Western Reserve University, 1963), p. 199.

[11]Bernard K. Dennis, "Financing a Technical Information Center," Information Retrieval Management, ed. Lowell H. Hattery and Edward M. McCormick (Detroit, Michigan: American Data Processing, Inc., 1962), p. 61.

summarizes the problems by stating that, "To plan and direct the center's programs and activities, one must be a professional in the technical information handling field and a business manager at the same time."[12] The center's workload is forecast annually on the basis of expected service activity, and a corresponding cost structure is established so management can determine the required funding. A summary of the center's cost structure reveals the heavy committment for labor costs since salaries amounted to 55.7 per cent of the total operating costs in 1961. Other major cost items were data processing (11.5 per cent), acquisitions (5.6 per cent), overhead (12.2 per cent), and office services (3.6 per cent).

Dennis suggests that a center has a distinct advantage if it can sell its services directly to clientele since it will be able to broaden its funding sources and not be limited to financing as an overhead item. The latter method may produce a precarious situation in times of a "monetary squeeze" on the part of the funding organization. Management subsidy, direct sales within the company, and direct sales externally are employed by the center, but the organization intends to increase the proportion of the latter two methods in the future. However, Dennis does not discuss whether or not cost accounting methods are utilized for the determination of realistic service costs although prices must be designated in some manner for the direct sales. It appears that the cost control measures for General Electric's center are applied only to the amount of the actual cost items, without any attempt to distribute scientifically the expenses to the information services.

---

[12] *Ibid.*, p. 75.

Overmyer discusses the cost and operational experiences of the American Society for Metals Documentation Service.[13] The costs of conducting two types of literature searches, bi-weekly (current awareness) and retrospective, are examined. Each search is divided into the following five steps for costing purposes:

1. Analyzing the question.
2. Structuring the question in a Boolean algebraic form.
3. Automatic encoding and searching on the computer.
4. Reviewing the output of the system.
5. Transmitting answers to the subscribers.[14]

The unit search costs were computed on the basis of a series of average hourly rates applied to the labor hours recorded for the individual searches. A portion of the engineer's salary, a charge for the use of incidental equipment, and a share of overhead were included. Unit costs were determined for three categories of searches that differ depending on the complexity of the problem involved. However, the author does not disclose the criteria used to define the complexity, so the classification is limited for comparison with the performance of other centers. Figures 2-1 and 2-2 illustrate the unit costs that were calculated for retrospective and bi-weekly searches, respectively.

---

[13] LaVahn Overmyer "An Analysis of Output Costs and Procedures for an Operational Searching Service," American Documentation, XIV (April, 1963), p. 123.

[14] Ibid., p. 126.

Figure 2-1

Unit Retrospective Search Costs

Low complexity	$105.31
Average complexity	$129.18
High complexity	$150.48

Figure 2-2

Unit Bi-weekly Search Costs

Low complexity	$ 7.90
Average complexity	$ 31.77
High complexity	$ 53.07

Overmyer hypothesizes that a wide range of unit search costs is inevitable due to the nature of the activity. Among the factors responsible for this variation are:

1. The complexity of the question and the structure required to describe the request.
2. The number and distribution of "hits." (A hit is defined as a relevant source of information.)
3. The number of tapes to be searched.[15]

Overmyer suggests that the uncertainty concerning the number and complexity of the searches requested from an information center creates a critical problem. The issue is compounded by the fact that the labor costs are relatively fixed during a particular time period. He summarizes the result of this phenomenon in the following manner:

> Obviously the total fixed costs will change very little in relationship to the volume of work, but the fixed costs per search will decrease as the number of questions to be answered increases.
>
> Personnel requirements loom as the greatest concern. We cannot afford to be overstaffed, nor do we want to run the

[15] *Ibid.*, p. 136.

risk of weakening our service by a lack of well trained personnel.[16]

Dougherty, head of the Acquisitions Department in the University of North Carolina Library, conducted a study to evaluate the operating efficiency of the Chemical-Biological Coordination Center.[17] He admits that accurate cost studies were not conducted so the analysis reveals conflicting estimates. Retrieval costs were estimated at $150 per request, based on a proportional share of total operating costs. However, the author does not disclose the costing technique involved or the costs that are included in this unitary figure.

Berul conducted a study to compare the operating costs of two unidentified technical information centers.[18] Only one of the centers has a computerized searching capacity so a comparison of the two sets of service costs reveals wide variations. However, the expenditures for labor, reproduction, equipment rentals, postage, and administrative charges are approximately equal. Another interesting disclosure is the fact that the labor costs for both centers comprise approximately 60 per cent of the total operating costs. This relationship compares closely with the figure of 55.7 per cent that was disclosed by Dennis for General Electric's technical information center. Consequently, both studies reveal the heavy labor committment required to operate a center.

---

[16] Ibid., p. 126.

[17] Richard M. Dougherty, "The Scope and Operating Efficiency of Information Centers," College and Research Libraries, XXIV (January, 1964), p. 7.

[18] Lawrence Berul, op. cit., p. 7-1.

Berul hypothesizes that the cost of information searching is sensitive to several independent factors such as the timeliness of a required response, the size and structure of the information file, the complexity of the question, and the processing speed of the equipment.[19] Another interesting feature of Berul's analysis is his comparison of the cost of a search of average complexity at the American Society for Metals with the average cost of a retrospective search at the computerized information center that he examined. The two figures compare favorably since the former, as reported in the Overmyer article, amounted to $129 while the latter was $105. However, Berul does not define a measurement of complexity, so both studies are affected by the same deficiency.

Marrow and Snyderman describe a technique used by the Science Information Exchange for the distribution of computer storage and retrieval costs in the information searching process.[20] Computer activities are grouped into three categories for costing purposes. Batched jobs are performed when several searches are executed concurrently during a single pass through the information file, and the cost of each search is computed by distributing the total computer time proportionately with the number of subject terms identified. Single jobs are accomplished when one search is performed at a time, and all of the computer costs incurred are charged to the single job. The third category is maintenance time which improves the quality and current status of the

[19] Ibid., p. 7-6.

[20] Harvey Marrow and Martin Snyderman, Jr., "Cost Distribution and Analysis in Computer Storage and Retrieval," American Documentation, XVII (April, 1966), p. 89.

information file. Since these costs are incurred so the information searching process operates efficiently, they must be charged to the other two types of jobs.

The authors develop the following mathematical framework to use for a systematic distribution of the computer costs:

1. $T = B + S + M$

where: T = total computer time

B = total computer time for batched jobs

S = total computer time for single runs

M = total computer time for maintenance

2. $d = D/T$

where: D = total computer costs for a time period

d = average hourly computer cost for the period

3. $C_B = Bd$ = cost of running batched jobs

$C_S = Sd$ = cost of running single jobs

$C_M = Md$ = cost of running maintenance

$n1$ = number of batched jobs

$n2$ = number of single jobs

4. The maintenance computer costs are distributed to the searches in proportion to the use of the file. To do so, C_M is divided into the following:

$$C_M = \frac{B}{(B+S)} C_M + \frac{S}{(B+S)} C_M$$

5. Then the adjusted unit cost for batched and single jobs is:

$$c_b = \frac{C_B + \frac{B}{B+S} C_M}{n_1}$$

$$c_s = \frac{C_S + \frac{S}{B+S} C_M}{n_2}$$

The authors hypothesize that the main advantage of this procedure is that the adjusted unit costs are a function of the following independent variables:

1. The total monthly computer usage.
2. The ratio of the number of hours spent on maintenance, batched, and single jobs.
3. The number and type of batched and single jobs.[21]

Proposed Cost Control Concepts

Peters suggests that a cost accounting system should provide the management of a technical information center with three types of information: (1) a quantitative evaluation of the work in progress; (2) data for cost control; (3) data for deciding such matters as changing the price or dropping an unprofitable activity.[22] He presents the framework of a job order cost system which he believes is feasible for information retrieval. The costs incurred for each job are recorded on a job order cost sheet which may be a computer print-out if the center has an electronic data processing capacity. All direct materials and labor traceable to a specific job are recorded on the sheet, and overhead is applied to the job on the basis of a standard rate.

---

[21] Ibid., p. 94.

[22] Alex Peters, op. cit., p. 107.

Each staff member records his work activity on a weekly time sheet that is the source document for the labor charged to the job order cost sheets. An overhead rate is determined prior to the beginning of a period by dividing the estimated overhead costs by the estimated activity, and materials are recorded on requisition forms. When a job is finished and distributed to the client, a summation of the three classes of expenditures represents the total cost of that particular service. At the end of each month, the expenses of the various jobs are transferred to a monthly ledger which represents a summarized accounting of the work performed by the center.

Peters summarizes the validity of cost control techniques for a technical information center in the following way:

> I believe that a technical information center should and can be run financially like any research laboratory considered as a unit in a large research complex. From the point of view of the control system and budget, there is no essential difference between the functions of a technical information service and those of a research laboratory, a management consulting service, or an engineering consulting service.[23]

Bryan and Carroll discuss various accounting and budgeting concepts applicable in library operations.[24] They suggest a fund accounting system consisting of such records as a general ledger, payroll ledger, fixed asset ledger, and cash receipts book.[25] Each account in the general

---

[23]Ibid., p. 104.

[24]W. W. Bryan and B. W. Carroll, "Public Library Budgeting and Accounting," Illinois Libraries, XXXXII (June, 1960), p. 384.

[25]The term, fund, is defined as, "A sum of money or other resources segregated for carrying on specific activities or attaining certain objectives, in accordance with special regulations, restrictions, or limitations and constituting an independent fiscal and accounting entity." National Committee on Governmental Accounting, Municipal Accounting and Auditing, No. 14 (Chicago, Ill.: National Committee on Governmental Accounting, 1951), p. 234.

ledger reflects the current status of the budgeted versus the actual expenditures. The other two ledgers are used to record the transactions connected with the payment of wages and salaries as well as any investment in property, buildings, and equipment. The use of the control system presents information for cost performance evaluation at the end of a given time period and insures that the funds appropriated for the library are accounted for accurately. However, since the system is oriented solely toward financial accounting, it does not facilitate the distribution of costs to the services.

Nitechi presents two cost accounting forms designed to provide "a simple guide to aid the libraries to determine the unit cost of technical services of a library."[26] However, the costs recorded on these forms are estimated figures rather than amounts generated from service cost measurement. The first form provides a classification of the various direct costs such as professional salaries, clerical salaries, and supplies based on their estimated use in the ordering, cataloging, and processing services. A more detailed functional breakdown within these services also exists.

Such indirect costs as personnel overhead, depreciation, rentals, maintenance, and miscellaneous expenses are distributed on the second form. Since these items are indirect charges, the estimated amounts are allocated only to the various departments (ordering, cataloging, and processing) without any further classification.

---

[26] Andre Nitechi, "Cost Accounting Forms," Michigan Librarian, XXIX (December, 1963), p. 19.

Brutcher, et. al. attempt to integrate theoretically sound cost accounting principles with the information retrieval function.[27] They hypothesize that library budgeting, which has dominated past cost control practice, is only as good as the basic costs upon which it is established. They further suggest that the use of cost accounting is mandatory for reliable cost information. A comparison of an information retrieval function and a typical business firm is made to defend the use of cost accounting techniques in the former type of operation.

> If we consider the functions of a profit-making firm, the operations consist of (1) acquiring the material, (2) processing the material, and (3) delivering the processed material. In simpler terms, the main functions are purchasing, production, and selling. The library also performs such functions. In the library, these functions are called acquisitions, cataloging, physical preparation, and circulation.[28]

Brutcher, et. al. conclude that generally accepted cost accounting principles should be applicable in a library operation. Both process costing and job order costing are examined and shown to be appropriate for particular library functions. Process costing is defined as a technique by which the direct costs of material and labor as well as a fair share of overhead costs are charged to various cost centers during a specified time period.[29] Job order costing is a method through which all of the costs consumed during the production process are charged to specific jobs.

---

[27]Constance Brutcher, Glen Gessford, and Emmet Rixford, "Cost Accounting for the Library," Library Resources and Technical Services, VIII (Fall, 1964), p. 413.

[28]Ibid., p. 415.

[29]Ibid., p. 416.

The authors develop a process costing framework with cost centers for ordering, cataloging, preparations, circulation, book selection, reference, and literature searching. Once the total costs are accumulated for a given time period, average unit costs are computed by dividing the total by the productivity of the function. The computation procedures of the average unit costs of the services performed in the seven cost centers are illustrated in Figure 2-3.

Figure 2-3

Average Service Costs

1. Unit cost of ordering = $\frac{\text{Total ordering cost}}{\text{Volumes ordered}}$

2. Unit cost of cataloging = $\frac{\text{Total cataloging cost}}{\text{Volumes cataloged}}$

3. Unit cost of preparations = $\frac{\text{Total preparations cost}}{\text{Volumes processed}}$

4. Cost per loan = $\frac{\text{Total circulation cost}}{\text{Volumes loaned}}$

5. Cost per title selected = $\frac{\text{Total selection cost}}{\text{Titles selected}}$

6. Cost per reference question = $\frac{\text{Total reference cost}}{\text{Number of questions}}$

7. Cost per search = $\frac{\text{Total search costs}}{\text{Number of searches}}$

The authors admit that the biggest disadvantage of the process costing technique is that differences in the service units are disregarded in the averaging process as the costs are not charged specifically to the related production. For example, the cost of all literature searches performed during a particular period would be the same even though the complexity of the individual problems normally will cause varying unit costs.

Job order costing is recommended when the different service units are readily identifiable. Each unit is accounted for as a unique job, and the usage of direct materials, labor, and overhead is recorded on a job order cost sheet. When a job is finished, the total cost is calculated by summing all the costs that have been incurred either directly or indirectly for that particular unit. The end result is more nearly precise than the average costs which are computed by process costing and reveals any cost differentials that exist. The authors suggest that the literature searching, acquisition, and cataloging functions are all suitable for job costing. A hypothetical job costing model is developed to illustrate the use of the method in a library operation.

Bourne and Ford developed a computer program that simulates the expected operating costs of an information system.[30] The program contains descriptions of the operating performance, costs, and the interaction of all the components of a proposed information system. An information retrieval operation is simulated over a specified time period to determine the required equipment, personnel, and operating costs. The greatest advantage of the model is the fact that a complete information system can be analyzed without an actual investment in the process.

Such cost data as labor wage rates, equipment purchase or lease costs, supplies, and miscellaneous expenses are determined for a proposed information system. However, the authors admit that the reliability of the simulation results is highly dependent on the selected cost figures.

---

[30]Charles P. Bourne and Donald F. Ford, "Cost Analysis and Simulation Procedures for the Evaluation of Large Information Systems," American Documentation, XV (April, 1964), p. 142.

In the article, the cost information is based strictly on estimates so a lack of valid data may restrict the model's effectiveness.

COST LITERATURE - RESEARCH AND DEVELOPMENT

Fundamental Concepts

Villers suggests that, "While it is desirable to give the research people and their supervisors freedom of action, it makes sense only if adequate recording shows that the time spent in one or another direction has been within the expected limits."[31] An accurate recording of the actual expenses consumed for the various research projects is necessary to achieve this objective. However, the author strongly advocates that the two extremes of labor cost control must be avoided due to the nature of the work force.[32] One adverse situation occurs when the engineers and scientists are required to report the time they "think" they have spent on various projects during a given period. The result is a cost estimation system which is of marginal value for managerial purposes because of the inexact nature of the cost data. The other extreme is to require the research personnel to account for every minute for which they are paid. The author believes that the latter approach may satisfy the bookkeeping function, but will be a continual source of annoyance for the staff. The most salient feature of this analysis is that a particular operation should find a labor control system that generates reliable cost information somewhere between the two extremes.

---

[31] Raymond Villers, Research and Development: Planning and Control (New York: Financial Executives Research Foundation, Inc., 1964), p. 81.

[32] Ibid., p. 144.

McFadden contends that the unique nature of research work demands a specialized accounting system.[33] An efficient cost control system must be realistic in terms of the operating conditions, yet it must assist in the achievement of organizational goals by providing accurate cost information. The author hypothesizes that the required specialized accounting will necessitate a revision of generally accepted cost accounting principles.

> Certainly it is not possible to say to a scientist: "Here are 'X' dollars. Within thirty days you must discover a new drug to cure cancer, invent a telescope which will employ no lenses, create an automobile to operate efficiently on water instead of gasoline, or find a cheap and plentiful substitute for uranium."[34]

Due to the uncertainty of the research results, it is impossible to establish realistic standards through normal industrial engineering methods. While management may be able to estimate realistically the time and expenditures necessary for desired results, unfavorable variances may be tolerated if their occurrence permits goal achievement. Shillinglaw asserts that due to the lack of normal manufacturing cost standards, the principal control technique is management's regulation of the annual appropriation.[35]

Quinn conducted an extensive study of the research evaluation systems used by several large industrial firms.[36] The results indicate

---

[33]James A. McFadden, Jr., "Cost Accounting for a Research Laboratory," N.A.C.A. Bulletin, XXXII (March, 1951), p. 823.

[34]Ibid.

[35]Gordon Shillinglaw, Cost Accounting - Analysis and Control (Homewood, Illinois: Richard D. Irwin, Inc., 1961), p. 410.

[36]James B. Quinn, "Study of the Usefulness of Research and Development Budgets," N.A.A. Bulletin, XL (September, 1958), p. 79.

that research and development costs cannot be controlled strictly through the use of a budget. The research budget is valuable mainly as a technique for planning the estimated costs of the individual projects. However, the author believes that the validity of the budgeting process terminates with the planning phase since any attempt to measure actual versus budgeted cost figures for control purposes is meaningless due to the subjective evaluation of the research results. In most manufacturing concerns, the units of output are well defined so such standards as price, rate, and efficiency can be determined objectively. Quinn explains the fallacy of this approach for the research and development function in the following way:

> Analysis of variances from the budget, as ordinarily practiced in accounting, requires definition of the units to be produced and development of a predetermined cost standard for each unit. Unfortunately, units of knowledge output cannot be defined before the knowledge is obtained, nor can the cost of producing an increment of new knowledge be predicted accurately enough to allow the use of the prediction of a cost standard.[37]

Horngren lists the following factors as being "peculiar" characteristics of research and development accounting:

> 1. The over-all amount to be spent is appropriated by top management much as is done for advertising.
>
> 2. The details of execution are in the hands of the research director, who necessarily must be a manager, an individual who sees that his personnel work effectively. This effectiveness is difficult to measure but is essential for a successful research program. Put another way, research must be managed, and yet research workers need a stimulating, unfettered environment accompanied by a minimum of red tape.
>
> 3. The central problem in appraising research performance is measuring effectiveness and benefit.[38]

---

[37] Ibid., p. 84.

[38] Charles T. Horngren, Cost Accounting - A Managerial Emphasis (2nd ed.; Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1967), p. 389.

In another article, McFadden asserts that cost control of research and development is restricted by the lack of certainty concerning the research results.[39] He suggests that the benefits from the various projects actually may increase with the passage of time as more knowledge is collected. Standard accounting methods, with an emphasis on cost comparisons by individual project, do not contribute useful management information because of the uncertainty related to the quality of the final product.

Harbrecht advocates a different role for the accounting function in the research and development process.[40] He suggests that the accountant's job is to provide the appropriate financial information, without even attempting to judge the effectiveness of the projects by the cost variances. Management has the responsibility to compare the actual versus budgeted cost relationship with a critical analysis of the quality of the research results. When the two aspects are evaluated simultaneously, management has a objective criteria with which to appraise the effectiveness of the research process. Harbrecht's approach minimizes the problem mentioned by other authors concerning the true meaning of unfavorable cost variances. If the project results are considered valuable enough, any unfavorable variances may be worthwhile.

McFadden also states that, "Whether or not it is possible to plan industrial research is perhaps the most controversial of all the

---

[39]James A. McFadden, Jr., "New Concepts of Information for Management Decisions - Research and Development," N.A.A. Bulletin, XL (August, 1959), p. 19.

[40]Robert F. Harbrecht, "Designing a System for Control of Research Cost," N.A.A. Bulletin, XLV (June, 1964), p. 3.

management questions facing modern industry."[41] Nevertheless, he believes that the proper planning of research expenditures is mandatory if a business is to survive in the technically advanced business world. The cost control procedures, however, should differ considerably from those employed in other types of business endeavor due to the fixed labor cost factor which McFadden summarizes in the following manner:

> With the shortage of scientific personnel in this country, the problem is to find adequate talent to staff the research effort. This element of cost, therefore, in the aggregate cannot fluctuate appreciably during a normal fiscal period.[42]

Since the fixed labor costs dominate the total cost structure, the primary control technique is one of forecasting the number of research personnel necessary for the established objectives and comparing the actual usage with the targets. The main benefit of such a system is that management dictates which projects and scientific problems will be worked on and then analyzes the relationships of the actual versus budgeted costs of the jobs.

McFadden also believes that a fundamental difference in objectives may limit the use of the control system. Management normally is profit-motivated in terms of goal achievement. However, the researchers often are concerned primarily with such factors as professional recognition and intellectual freedom. Changes in personal attitudes, business philosophies, and measurement criteria are necessary to reconcile the opposing objectives.[43] Otherwise, rigid cost control may be achieved at

---

[41] James A. McFadden, Jr., "Industrial Research Must Be Planned and Controlled," The Controller, XXIX (November, 1961), p. 527.

[42] Ibid., p. 529.

[43] Ibid., p. 531.

the expense of the technical quality of the research results or, conversely, a completely control-free operation may achieve satisfactory research objectives but at a prohibitive cost level.

Research and Development Cost Accounting

Research and development costs can be classified several ways, depending on the use of the information.[44] Among the possible groupings are the nature of the expense, research activity, responsibility, project, or product. When the costs are classified according to the nature of the expense, such items as salaries, supplies, materials, and equipment expenditures are presented in detail. Accounting for research costs by work activity enables management to measure the cost of operating a particular department.

When the expenditures are classified by responsibility, the manager who is accountable for the research results of a particular cost center also is responsible for the controllable costs incurred in the operation. Classification by project can be accomplished through a project cost card that discloses the actual versus estimated costs of an individual job. Product classification provides an analysis of the amount of research effort being exerted for the various products.

McFadden asserts that a job order or project order cost system usually is utilized for research and development cost control.[45] All of the direct costs such as labor, materials, supplies, technical services,

[44] Accountants' Cost Handbook, ed. Robert I. Dickey (2nd ed.; New York: The Ronald Press Company, 1960), p. 2-7.

[45] James A. McFadden, Jr., "Cost Accounting for a Research Laboratory," N.A.C.A. Bulletin, XXXII (March, 1951), p. 824.

professional services, traveling expenses, and equipment costs are charged to the appropriate projects as they are incurred. The indirect costs are distributed on the basis of a predetermined overhead rate which is applied to a realistic activity basis. All of the costs are recorded on a project cost sheet, one of which is established for each research job.

The research personnel register their activity on a monthly time sheet according to the hours worked on the various jobs, and an average hourly cost is determined each month for every employee by dividing the number of hours worked into the monthly salary. The average rate is used to distribute the individual's salary to the research projects performed during the month. The averaging procedure and the monthly time sheet obviously represent a departure from the rigid control system used in most manufacturing operations, but once again the accounting process is justified by the nature of the personnel.

McFadden proposes the following set of cost reports which are designed to provide a scientist with cost information that he can understand and use intelligently:

1. A cost summary on a current month and year-to-date basis, expressed in numerical characters, of all the projects embodied in the research.

2. Summary of the same year-to-date costs and appropriations, expressed in chart or graphic form.

3. The various costs, in chronological sequence, incurred on a particular project.

4. The same information as that presented in number 3 except that the cost elements are charted since this form of presentation is more easily understood by scientific personnel.[46]

---

[46] Ibid., p. 836.

Villers describes a research labor reporting system that requires an hourly increment as the smallest unit of measurement.[47] The scientists record their time on a weekly time sheet which the author believes generates sufficient precision, yet does not demand minute detail. The costs recorded on the time sheets are charged along with materials and overhead to the corresponding research projects. Periodic financial reports provide the responsible managers with detailed information concerning the costs of their projects, and the exact timing and nature of these statements will be a function of a particular organization's requirements.

A similar system is proposed by Harbrecht who hypothesizes that the cost control function should accomplish the following objectives:

1. The assignment of responsibility for all costs.
2. Authorization of all work before it is started.
3. Estimated and budgeted time and cost for each phase of the research projects.
4. Cost reports that show a comparison of actual and budgeted costs.
5. Charging of all research department personnel to work order numbers for research projects.
6. Charging of all other research costs directly to the projects or to an overhead account.
7. Allocating a share of the overhead costs to the projects on some reasonable basis.
8. Reports for management that are designed to help achieve the objectives of the research program.[48]

---

[47] Raymond Villers, op. cit., p. 145.

[48] Robert F. Harbrecht, op. cit., p. 4.

In order to accomplish these goals, Harbrecht recommends a project cost system in which cost centers are established throughout the research department. A work order number is assigned to each phase of the research projects and, whenever possible, the costs are charged directly to the work orders and cost center accounts. The indirect costs consumed during the operation are charged to overhead accounts, one of which is established for each cost center. A predetermined rate is utilized to distribute the indirect costs to the projects in a manner analogous to normal manufacturing overhead application. Since labor represents the largest cost element in most cases, a reliable time reporting system is mandatory, and Harbrecht suggests that the exact nature of the time card will be a function of a particular firm's requirements and capacity. Many companies utilize weekly or monthly labor reporting, but daily time records may be necessary in cases where rigid labor control is compulsory.[49]

Additional R & D Cost Control Applications

Carlisle characterizes cost systems for research and development as "more flexible, more effective in extracting management-oriented cost information from extremely complex situations, and more comprehensive in assimilating and synthesizing the vast amount of cost data connected with these projects."[50] He offers a cost system that has two basic characteristics: (1) It is a project cost system; (2) Cost centers are organized throughout the research department.

---

[49] Ibid., p. 6.

[50] Howard M. Carlisle, "Cost Accounting for Advanced Technology Programs," The Accounting Review, XLI (January, 1966), p. 117.

Cost codes are established on the basis of the work increments performed for each research project, and a responsibility accounting framework is utilized to achieve cost performance reporting in the organization. All costs related to the various work activities are charged to the appropriate cost center as well as a specific project. The source documents which confirm the different cost transactions are the traditional type found in manufacturing operations (Examples are labor time tickets and material requisitions).

Uniform cost codes should be established, whenever possible, so cost comparisons of the various projects can be performed effectively. However, the system should be flexible enough to provide the required cost control for any special projects undertaken by the organization. Carlisle concludes that the R & D cost system will be beneficial to management for cost identification and collection, performance evaluation, and cost control.[51]

Pflieger presents a cost ledger system that is designed to account for sponsored research contracts.[52] A work order number is assigned to each research project, and the costs incurred during a period are traced to the related job. Once again, cost centers are established, and a shop order cost ledger is utilized in each center to record the expenses of the individual research projects. At the end of every month, the billable costs of each project, determined by the terms of the research

---

[51]Ibid., p. 119.

[52]John H. Pflieger, "Control Accounting for Sponsored Research Contracts," N.A.A. Bulletin, XXXIX (March, 1958), p. 77.

agreement, are charged to a cost of sales account and credited to the appropriate cost center. The cost of sales account reflects the current status of the expenses incurred for all chargeable projects. The cost of any services performed by one organizational function for another cost center also is charged to the latter operation. The author suggests that cost performance efficiency is measured by the difference between the total costs of an individual cost center and the amount charged as billable costs.

A general ledger is organized on a responsibility accounting basis with a set of credit and expense accounts for each cost center. Since the individual centers are charged for all the labor, material, and overhead consumed during the operation and credited for the billable charges and work performed for other functions, a profit and loss statement can be prepared from the control ledger account. Such managerial functions as work load distribution and efficiency analysis are assisted by the profit and loss information which is generated for each cost center.

Schmieg describes a flexible budget that is similar to one used to control overhead costs in regular manufacturing operations (See Exhibit VIII for an example of a flexible budget).[53] Since management cannot predict accurately the annual research volume, the use of a fixed budget for overhead application may produce wide discrepancies. A flexible budget should minimize such problems since it can be adjusted for changes

[53] H. J. Schmieg, "Control of Overhead with a Variable Budget in a Research Operation," N.A.A. Bulletin, XL (August, 1959), p. 45.

in volume, and overhead objectives, at any activity level, are reflected realistically in the budget. Schmieg explains the procedure in the following way:

> In a research and development operation, the overhead expenses are incurred solely as a result of supporting direct engineering effort on all current projects. This application of direct labor effort depends on technical objectives and schedule end dates, both of which are subject to change at any time. In short, the variable type of budgets will not only provide an insight into how overhead expenditures react under extreme fluctuations of volume, but will also assure constant and consistent control under changing conditions.[54]

A predetermined overhead rate is selected from the flexible budget for the number of direct labor hours expected to be employed in the research function during a specified period. The rate is applied to each recorded direct labor hour so that overhead is charged to the projects. Monthly indirect expense reports, showing any variation between the actual and budgeted overhead, are used by management for control purposes. The resulting overhead variances are identical to the type calculated in a traditional cost accounting system. For example, a two variance analysis can be used to divide the total overhead variation, for explanatory purposes, into a budget and volume variance. The budget proportion is computed by relating the budgeted costs at the attained research activity level with the actual overhead expenses. The volume variance is calculated by comparing the budgeted overhead at the attained level of operations with the amount applied through the predetermined rate. Corrective action can be taken, whenever necessary, by the research director to determine the cause of unfavorable variances.

---

[54] Ibid., p. 46.

Gauss reports on the system used by the Upjohn Company to control the cost performance of several research departments.[55] Each project is assigned a code number when it is approved, and the research personnel register an approximate accounting of their work on a monthly time card. The cost sheets are recapitulated at the end of each month, and percentages of time expended for the various projects are used to distribute the total labor. Purchase requisitions are employed to charge materials directly to the projects, and overhead is distributed on the basis of the manpower assigned to each job. A monthly report is issued to provide management with a detailed analysis of the costs of each research project.

CRITIQUE OF THE LITERATURE

Scope

The limited body of literature that was considered potentially relevant for the design of a feasible cost system is reviewed in detail in the preceding sections of this chapter. The two main subsets of the literary work are the cost control concepts of information retrieval and those of the research and development function. The purpose of the final section is to summarize the pertinent results and limitations of the review in relation to the objective of this study.

---

[55]D. B. Gauss, "Reporting Departmental Costs of Research Projects," N.A.A. Bulletin, XL (September, 1958), p. 32.

Pertinent Results

An overwhelming majority of the authors believe that cost control in a technical information center is essential. Furthermore, several of the writers opine that a center should be operated as a business enterprise with the usual applications of managerial cost information. Comparisons of information centers with other service functions that employ cost control techniques support these beliefs. For example, the research and development cost literature indicates that requiring scientific personnel to record their work activity is realistic and justifiable as long as a preoccupation for minute detail does not dominate the procedure. All of the suggested cost systems include a labor time sheet that is used to record an objective classification of the research work. The proper form of labor reporting is shown to be a critical feature due to the large portion of labor costs required for such operations. Also, due to the character and scarcity of scientific personnel, the labor costs are relatively fixed since the labor force cannot be varied in proportion to service volume. Cost and operational information is mandatory if personnel requirements are to be forecast efficiently.

Most of the systems that are discussed contain the capacity to charge the costs to the appropriate service activity as well as the proper cost center. As a result, product costing and responsibility accounting are accomplished simultaneously. Another interesting feature is the utilization of either job order or process costing. Both techniques appear applicable for information retrieval costing, depending on the nature of the service. The product costs always are direct materials, direct labor, and overhead. Most authors suggest charging the first two costs directly to the services and allocating the overhead on the basis of a predetermined rate.

Also, the emphasis in R & I accounting is on the comparison of budgeted and actual costs. Project costs are forecast at the time of approval and the actual costs are accumulated for each job through a project cost system which is a form of job order costing. Periodic reports enable management to analyze any cost variances.

All of these characteristics are based on sound cost accounting theory and parallel those used in most manufacturing concerns. As a result, it appears that cost accounting for a technical information center will not require a completely new cost accounting philosophy, but merely a revision and alteration of generally accepted cost accounting principles.

Limitations

The predominance of cost estimation in the information retrieval field creates the most serious limitation found in the literature. While the need for actual cost measurement is recognized repeatedly, it seldom is attempted. Also, in those studies in which service cost data are presented, the authors fail to reveal the cost philosophy and techniques that are employed. The result is an inability to generalize concerning the costs of operating a technical information center. For example, several unit retrospective search costs are mentioned that appear to be approximately the same. However, one must be cautious in drawing this conclusion without information concerning the methodological approach used by the different centers in calculating the unit costs.

Until several centers—using a similar costing philosophy—reveal their cost accounting experiences, the limitation will continue to handicap the ability to generalise regarding information service costs.

Another limitation is the fact that none of the authors actually suggest a complete cost accounting system that could be installed and be functionally operational in a technical information center. Instead, they are concerned with more limited concepts such as the type of relevant information, costing philosophies, source documents, reports, or records. None of the literature reviewed attempts to integrate the current state of appropriate cost accounting concepts into an effective system.

Also, the uncertainty pertaining to the quality of the research results exemplifies a problem that also is prevalent for cost control in a technical information center. This issue has constrained R & D cost accounting from becoming as effective as the cost procedures employed in regular manufacturing where a well defined production quality level usually exists. When the quality level is known and fixed, cost variances provide an objective measure of operating efficiency. Even if the information retrieval process is operating efficiently, uncertainty still exists as to the client's benefits from the final product. However, as is suggested by several authors, the uncertainty of production quality should not prohibit the use of a cost system for such functions, but should only qualify the use of any variances between actual and budgeted costs. If an efficiency measurement of the information retrieval operation is desired, the costs and the quality of the final product must be evaluated simultaneously, as was suggested for the research and development function.

CHAPTER 3

MANAGERIAL COST ACCOUNTING CONCEPTS

INTRODUCTION

The research questionnaire survey presented in Exhibit II and an analysis of the literature review chapter disclose numerous perceptions of cost procedures for information retrieval operations. The purpose of this and the two succeeding chapters is to extend the conceptual framework into a computerized managerial cost accounting system which this author proposes is appropriate for a NASA Regional Dissemination Center. It is assumed that the centers already possess a financial accounting capability, sufficient to record and disburse such expenditures as payroll, computer time, travel, equipment rental, and supplies. An objective distribution of these expenses to the information services or the time period is achieved with the proposed cost accounting system, the records of which are controlled by and subsidiary to the financial accounting system. Consequently, the proposed managerial cost accounting system is designed as a subset of the overall accounting effort. Essentially the same principles and procedures are valid, however, if management elects to operate the cost system independent of the general financial accounting system.

Neuner and Frumer state that a cost accounting system "is made up of a series of forms, journals, ledgers, accounting entries, and management reports integrated into an efficient series of procedures so that unit costs can be determined promptly and used in managerial decisions."[1]

---

[1]John J. W. Neuner and Samuel Frumer, Cost Accounting - Principles and Practice (7th ed.; Homewood, Illinois: Richard D. Irwin, Inc., 1967), p. 8.

In the present chapter, the essential components of the system and the related cost accounting techniques are developed. Specific examples of the necessary forms and records are utilized for illustrative purposes only since, in most cases, they have no unique content. The managerial framework shown in Figure 1-1 represents the basic foundation of the system, the major objective of which is to provide management with relevant and timely cost information for planning, controlling, and decision-making purposes. Matz, et. al. suggest that cost accounting in general is charged with the responsibility for:

1. Determining costs and profit for an accounting period.
2. Creating inventory values for costing and pricing purposes and, at times, controlling physical quantities.
3. Aiding and participating in the creation and execution of budgets.
4. Establishing methods and procedures that permit control and, if possible, reduction or improvement of costs.
5. Providing management with information in connection with problems that involve choice from among two or more alternative courses (analytical processes).[2]

A thorough discussion of the actual utilization of the managerial cost accounting system for service cost measurement is deferred to the following two chapters. Chapter 4 contains an explanation of the procedures used to record and process all costs accompanying the Retrospective Search Service. In Chapter 5, the techniques associated with the Selective Dissemination Service are developed.

---

[2]Adolph Matz, Othel J. Curry, and George W. Frank, Cost Accounting (4th ed.; Cincinnati, Ohio: South-Western Publishing Company, 1967), p. 13.

The model system was operated at the Aerospace Research Applications Center (ARAC) to test the service cost data for consistency between monthly periods. An analysis of variance model, which was used to test the differences between the monthly average search costs of the trial period, also is presented in this chapter. The results of the test period are disclosed in Exhibit III, Appendix IV.

RESPONSIBILITY ACCOUNTING

Basic Concepts

Responsibility accounting provides a mechanism by which the controllable costs of a NASA Center not only are charged to the related information service but also are traced to the person accountable for the performance of the work activity. A center's organizational structure is divided into a group of responsibility units, commonly referred to as cost centers. The National Association of Accountants defines a responsibility unit as, "an organizational unit engaged in the performance of a single function or a group of closely related functions having a single head accountable for the activities of the unit."[3] Shillinglaw suggests that a responsibility unit may be a department, a section of a department, or even a group of departments.[4]

The most critical feature of responsibility accounting is a well-defined organization in which each responsible person knows what is

---

[3]National Association of Accountants (formerly National Association of Cost Accountants), "The Analysis of Manufacturing Cost Variances," N.A.C.A. Bulletin, XXXIII (August, 1952), p. 1549.

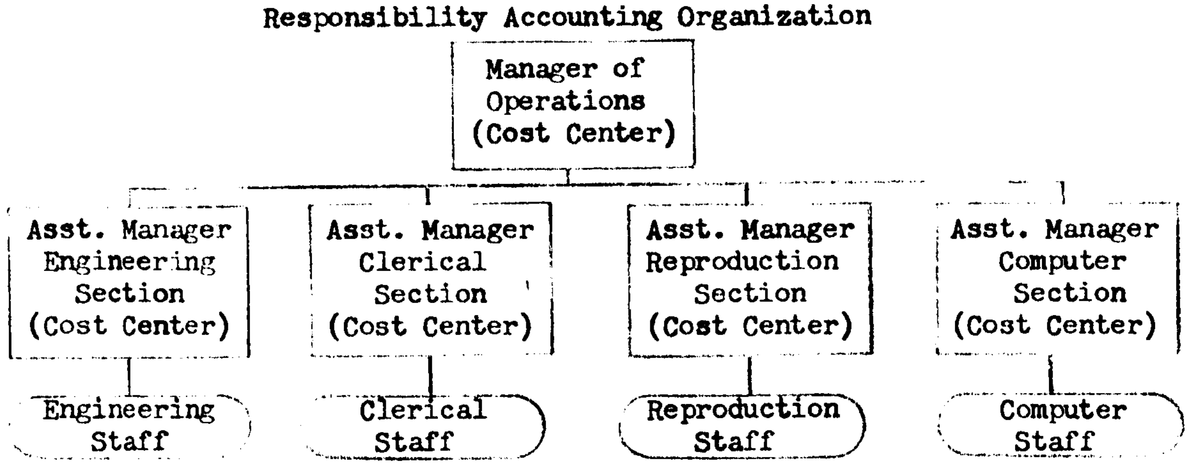
[4]Gordon Shillinglaw, Cost Accounting - Analysis and Control (Homewood, Illinois: Richard D. Irwin, Inc., 1961), p. 37.

expected of him and possesses the authority to accomplish his objectives. Cost centers are established to coincide with the organizational structure, and each manager responsible for a given work activity also is accountable for the related controllable costs. Horngren defines the controllable costs as those items that may be directly regulated or influenced by a responsible manager during a given time period.[5] The responsibility accounting concept is extended up through a center's chain of command, and managers who maintain authority over the work activity of subordinate cost centers also are responsible for their controllable cost performance.

The most feasible division of a given NASA Center into a set of cost centers depends on such factors as size, services, capacity, operating procedures, and organization. For example, Figure 3-1 shows the responsibility units organized for the trial application of the managerial cost accounting system at ARAC. Cost centers are established for the four

Figure 3-1

Responsibility Accounting Organization



---

[5] Charles T. Horngren, <u>Cost Accounting - A Managerial Emphasis</u> (2nd ed.; Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1967), p. 273.

major functions of the information production process—engineering, clerical, reproduction, and computer. The assistant manager responsible for a given section's work performance is charged with the cost center's controllable costs consumed during a monthly period. Since the manager of operations is accountable for the job performance of the four sections, he also is answerable for the controllable costs of the subordinate responsibility units as well as those incurred in his own cost center.

Budgeted Cost Targets

Cost targets are established by estimating the consumer demand for the information services during a given period and converting these data into budgeted costs as described below. Service activity is forecast on the basis of management's evaluation of such factors as past performance, current clientele acceptance, the number of customers, general economic conditions, and service acceptance trends. Forecasting the magnitude and assortment of information services provides an objective basis for planning the production resources required for the selected activity volume. Past information from the cost accounting system can be utilized effectively to predict the requirements for such resources as manpower, supplies, computer time, travel, and equipment. The budgeted quantities are established as the cost performance targets of the managers responsible for the related cost centers.

Cost Performance Information

The managerial cost accounting system generates a monthly computer printout which indicates the actual cost performance of each responsibility unit. Cost data are summarized and presented in a monthly performance report that reveals a comparison of the actual and budgeted costs for each cost center. The budgeted costs represent the targets forecast for the expected service activity volume during the planning stage of the operation. If the actual cost performance relates unfavorably with the predetermined targets, managerial action is required to determine the cause of the variance. The monthly performance report is designed to emphasize any deviations from the budgeted costs. (See Exhibit XI for an example of such a report.) Consequently, cost control is achieved throughout a technical information center on the basis of management by exception which Anthony describes as follows:

> A management control system operated on the exception principle is one in which management's attention is focused on the relatively small number of items in which actual performance is significantly different from the standard. When this is done, little or no attention need be given the relatively large number of situations where performance is satisfactory.[6]

In a sense, cost performance data are more essential for a successful operation in a NASA Center than that of a typical business firm which employs the responsibility accounting concept to measure deviations from a predetermined profit plan. The financial breakeven objective of a NASA Center prevents the possibility of absorbing adverse operating cost performances with a share of the profit margin or prior years' accumulated earnings. Instead, an operating deficit will result when actual expenses exceed those budgeted since costs provide the most objective basis for prices and revenues must be equal to costs for long-run survival. Management of a NASA Center must estimate future costs

---

[6]Robert N. Anthony, Management Accounting (3rd ed.; Homewood, Illinois: Richard D. Irwin, Inc., 1964), p. 373.

accurately and insure that a sufficient amount of revenue will be available. Historical cost data are projected to the expected future service volume during the planning process for a given year, and the service prices should be calculated to cover all operating costs. The essential features of a proposed pricing policy are discussed in a later section of this chapter. If the actual cost performance relates favorably with the budgeted figures, the breakeven objective of a NASA Center should be accomplished. However, unfavorable cost variances must be investigated immediately to avoid the possibility of incurring an operating deficit. The responsibility accounting process provides a continuous and timely procedure for detecting potentially unfavorable cost performances.

COST ELEMENTS AND MEASUREMENT

General Nature

The purpose of this section is to describe the most essential cost elements incurred by a typical NASA Center and the fundamental accounting procedures employed to accumulate, for computerized data processing, the expenses related to the information searching operation. In the following section, a computerized mechanism is developed through which the cost data can be processed and reported so the cost accumulation methods must be designed to provide efficient input devices to the electronic data processing function.

The total operating costs of a NASA Center can be dichotomized into two main segments, service and nonservice costs. The costs consumed during the information production process represent the service costs since they are charged, either directly or indirectly, to the final products. Most of the cost accounting concepts developed in this study are directed toward objective service cost accumulation, processing, and reporting procedures. The second major cost classification is that of the selling and administrative functions. Formal cost accounting techniques are not employed to relate the nonservice expenditures to a work activity measure due to their nature, but they must be included in the study because of their relative magnitude and corresponding impact on the cost basis of service prices.

Direct Labor

Direct labor refers to the work elements employed during the information production process that can be traced realistically and economically to the services. The primary labor expense is the engineering function which is responsible for designing an appropriate search strategy and evaluating the information citations identified by the computer. Assistance is provided the engineers by other labor such as clerical, reproduction, and computer. In many cases, the nonengineering work can be traced to specific information services, and if it represents a significant cost item it should be recorded as direct labor. Consequently, direct labor reflects the segment of the work performance that is an integral part of the information products.

Work activity that cannot be associated realistically with the services should be classified as indirect labor for reporting purposes. Supervisory work, attendance at meetings, maintenance, reading by the engineers to update their current awareness of the literature, idle time, and janitorial labor are examples of the indirect category.

A variety of recording procedures are possible for the labor reporting function at the source of the work activity, ranging from a simplified labor time ticket to a sophisticated computerized reporting system.[7] The choice of a feasible procedure depends on the required detail and accuracy of the labor data. The primary objective of time reporting in a NASA Center, for purposes of this study, is to achieve a feasible balance between realistic cost data and the possibility of a burdensome reporting function. It is hypothesized from the literature review and research questionnaire survey that a daily increment provides sufficiently accurate detail without unduly annoying the engineering staff.[8]

A daily time ticket that should provide an efficient and economical accounting of the labor performance is illustrated in Exhibit IV. The form has the advantage of showing a complete description of an employee's daily work performance, and furnishes sufficient detail for the computerized data processing function of the cost system to print an exacting classification of the reported labor performance for each cost center. The essential features of the time reporting record are the individual's name, date, cost center, set of cost codes, and time scale. A coding system is used to identify the various work activities of the information center, and the employees simply line across the sheet when they begin a different job. The work activity coding system employed for

---

[7]See the following reference for a detailed description of a range of labor reporting techniques: John J. W. Neuner and Samuel Frumer, op. cit., p. 171.

[8]The opinions of several managers of NASA Centers who were interviewed during the research stage of this study support the proposal of a daily labor reporting system.

the test period at ARAC is illustrated in Appendix I. The electronic data processing function performs the essential operations for a summarization, classification and presentation of the relevant labor cost information so the human inputs to the system are minimal. The computer charges the direct labor costs reported on the time tickets to the related information services and the indirect expenses to overhead accounts.

Direct Sundry Expenses

The term "direct sundry expenses" is used in this study to define a variety of service costs incurred in a typical NASA Center. These costs compose a major portion of the total operating expenses, and when they can be identified with specific services they should be treated as direct service costs. The most essential items are computer time, telephone calls, reproduction costs, and travel. In a typical manufacturing firm, the incurrence of such expenses normally would be treated as overhead without attempting to charge the items to the products since they are miscellaneous costs in relation to the overall production process. The importance of the expenses in an information searching operation, however, demands their treatment as direct service charges if accurate unit costs are to be attained.

Several source documents are necessary to record the direct sundry expenses as they are consumed during the operation. Examples of the records used to accumulate such costs during the test period at ARAC are discussed in this section. A production work order, shown in Exhibit V performs a dual function for the reproduction operation as it represents the source document through which the costs are charged to the services and also furnishes an efficient work scheduling device. Examples of the reproduction charges are equipment rental costs and copying supplies. The reproduction operation is analogous to a manufacturing job shop which functions as a mechanized assembly line so the work order form should minimize the possibility of queueing problems in the sequential usage of the equipment.

Computer time represents a major expenditure for a NASA Center so an objective distribution to the services is essential. The total computer time can be divided, for recording purposes, into the direct and indirect segments. The former element is incurred to search the information file for relevant citations for both the Retrospective Search Service and the Selective Dissemination Service. The other segment of computer time is required for maintenance and development purposes in the information retrieval system. A computer program, presented in Appendix II, provides the necessary operating instructions for the machine to record the time required for the various runs of a given month. A set of codes should be established for the different types of computer operations employed by a center, and the machine will record the time spent on the different jobs concurrently with their performance.

Long distance telephone calls usually are required to clarify the exact nature of an information request submitted by a client. A form such as the one illustrated in Exhibit VI provides a detailed record of the reason for each call and furnishes the necessary information for charging the related costs to the services or to operations overhead. Travel expenses often are incurred as the engineers interrelate with clientele. Whenever the travel is related to a specific service, it should be charged accordingly. A travel voucher such as the one shown in Exhibit VII supplies the necessary information for the costing process.

All of the source documents suggested in this section are designed to facilitate computerized data processing. The source information is accumulated on a monthly basis and transferred to punched cards as inputs to the computer. A computer program, which is discussed in a later section, provides the necessary operating instructions to the machine for an objective classification and distribution to the information services. The result of the process is a monthly computer printout which identifies the direct sundry expenses consumed during the period for the information services. The exact classification of the costs by service on the computer printout depends on whether job order or process costing is employed during the production process. The costing methods utilized for the Retrospective Search Service and Selective Dissemination Service are described in Chapters 4 and 5, respectively.

Operations Overhead

All indirect service costs are included in the operations overhead classification which comprises such items as depreciation, rent, indirect labor, idle time, staff meetings, engineer reading of the current literature, supervision, insurance, and postage. Anthony describes the justification for an overhead category as follows:

> Some costs are classified as overhead because it is impossible to associate them with products. Who can say how much of building depreciation or of a factory

> superintendent's salary actually belongs to each unit of product manufactured? Other costs are classified as overhead because it is not convenient to trace them directly to products, even though it would be possible to do so.[9]

Despite the fact that the operations overhead costs cannot be associated directly with the production process, a reasonable portion must be charged to the information services for the calculation of realistic search costs. The use of a predetermined overhead rate calculated from the forecast service activity level of a flexible overhead budget provides an objective technique for the distribution of the indirect costs. A work activity measure such as direct labor cost, direct labor hours, or service units is selected as the basis of a flexible budget which consists of a series of overhead budgets for varying service volumes. The flexible budget concept adjusts for the fact that a portion of total overhead is a variable cost which changes in proportion to the work activity. The anticipated service activity is forecast for an annual period, and the corresponding budget level is utilized for the selection of a predetermined overhead application rate.

The choice of a realistic service activity level is extremely critical since the predetermined rate will vary as the fixed overhead costs are distributed over different volumes. An abbreviated segment of a flexible budget is shown in Figure 3-2 to illustrate this relationship.

Figure 3-2

Flexible Operations Overhead Budget

Direct Labor Costs	$ 80,000	$100,000	$120,000
Variable Operations Overhead	160,000	200,000	240,000
Fixed Operations Overhead	200,000	200,000	200,000
Total Operations Overhead	360,000	400,000	440,000
Predetermined Rate	$ 4.50	$ 4.00	$ 3.67

[9] Robert N. Anthony, op. cit., p. 426.

Horngren suggests that the normal activity represents a satisfactory prediction of capacity utilization since it refers to the average consumer demand over a span of time long enough to reflect expected seasonal, cyclical, and trend factors.[10] The use of the same rate over a lengthy time period (normally a year) eliminates many deviations in unit costs from variations in service activity or total overhead expenses. As is mentioned in Chapter 1, the fixed cost committment of a NASA Center creates a basic need for a stabilizing process. When the service activity is less than that forecast for the establishment of the work force level, increased indirect labor expenses will result, thus changing the unit cost if the actual overhead is allocated to the actual service volume. The use of the predetermined rate from the flexible budget should minimize the problem and stabilize the unit search costs from period to period. A complete description of the procedures required for the calculation of a predetermined overhead rate and an illustration of a flexible budget for a NASA Center are presented in Exhibit VIII. The computer program utilized for the data processing function in the cost system has been designed to instruct the machine to calculate the applied operations overhead on the monthly cost performance printout. The predetermined rate selected from the flexible budget is recorded on a punched card (see Appendix I) for computerized processing. The activity basis employed during the system's trial run at ARAC was direct labor costs due to the nature of the operation and the importance of the engineering labor. Consequently, the computer calculates the correct overhead concurrently with the direct labor costs charged to the information services. The

---

[10]Charles T. Horngren, op. cit., p. 234.

activity basis of the program can be adjusted, however, to coincide with specific requirements of a given center. A discussion of the process required to analyze the difference between the applied operations overhead and that actually incurred is deferred to the "Managerial Reporting" section of this chapter.

Selling and Administrative Expenses

The selling and administrative expenses of a NASA Center must be accounted for as period expenditures rather than service costs because of their nature. The primary control technique for such costs is the employment of the responsibility accounting process discussed earlier instead of a specific unit cost measurement. Since the selling and administrative expenses are not charged to the information services, they appear on the income statement as a deduction from the gross margin (revenue less service costs). The nonservice costs are not within the control process of the proposed cost system operation, but nevertheless must be considered in this study because of their impact on the total operating cost structure.

Selling expenses result from advertising, promotion, meetings, and direct selling to prospective clientele. Also, liason work with regular customers often is required to explain new information retrieval methods. Administrative expenses are incurred for the direction, control, and administration of a NASA Center. Most of the administrative expenses are fixed over a relatively wide range of service activity since the major items are top level management salaries.

The selling and administrative expenditures should be budgeted for each operating period and identified with specific cost centers. The responsibility accounting framework permits a periodic comparison of the budgeted and actual cost items for each responsibility unit. Since the objective of a NASA Center is to operate at a breakeven revenue level, a share of the selling and administrative expenses must be included in the cost basis of the pricing policy. Consequently, careful analysis must be performed for any unfavorable variances in the related cost centers. A technique for associating a fair share of the selling and administrative expenditures to the average search cost for each information service, retrospective search and selective dissemination, is presented later in this chapter.

DATA PROCESSING FUNCTION

Design Considerations

The cost data collected on the various source documents during the production process must be converted into managerial information through the data processing function. The author confronted a critical problem during the design of the cost system concerning the most feasible utilization of personnel and/or equipment for the data processing procedures. In recent years, the employment of the digital computer in various stages of an accounting system has become increasingly popular. The tremendous speed and flexibility of a computer offer a variety of potential applications in a cost accounting system.

The primary advantage of a digital computer is that it performs a data processing job faster than a manual effort, thus speeding up the paper-handling operation. Also, if great masses of data must be processed, the computer may provide a clerical labor savings. Another potential benefit from an automated system is that the two advantages listed above may allow an organization to retrieve managerial information that otherwise would not be attempted.

The utilization of electronic data processing equipment, however, necessitates substantial economic outlays for such items as equipment acquisitions or leasing, skilled labor, maintenance, and software development (programs, operating instructions, and procedural manuals). A feasibility analysis of the use of mechanical versus manual methods for the data processing requirements of a cost system depends on the cost-benefit relationship of specific applications. Nelson and Woods summarize the relevant considerations involved when they suggest that:

> The last decade has witnessed the development of the automatic computer as a business data processing device. This device, together with punched card, punched tape, and other data processing equipment now gives the accountant some very powerful systems tools. The wise use of such equipment is a tremendous challenge to the systems man, particularly since manual methods and devices have by no means been discarded. Even in the largest companies, manual operations are the most efficient for many accounting jobs. The accountant, therefore, must use a judicious blend of manual and automated methods in setting up or revising an accounting system.[11]

Selected Application

Several data processing stages of the proposed cost accounting system are potentially suitable for a computer application. Among the most relevant phases are cost transaction measurement, processing the source data, a permanent storage and periodic updating of the processed

---

[11] Oscar S. Nelson and Richard S. Woods, Accounting Systems and Data Processing (Cincinnati, Ohio: South-Western Publishing Company, 1961), p. iv.

cost data, and reporting the relevant managerial information. Each of these functions was analyzed critically to determine if an automated or manual effort should be employed. After considering the nature of a NASA Center's operation, services, production procedures, and necessary paper work volume, this author decided that an application of automated methods to the source information processing requirement would provide the most efficient overall data processing function. The majority of the paper work is generated during the recapitulation of the source information, and a low volume amount of clerical labor can satisfy effectively the other data processing requirements.

The primary computer program of the proposed cost accounting system provides the operating instructions to generate relevant cost data for an efficient transmission from the source information recorded during the production process to a manual cost accounting ledger. The program, written in FORTRAN, is designed to permit the utilization of the elementary set of source documents discussed in the preceding section. Since one of the objectives of this study is a cost system which requires a minimum amount of recording work by the operating personnel, the program's efficient coordination with the prescribed type of source documents is essential. Another feature of the program is that it will instruct the computer to classify and report the cost data in a form that allows a clerk to transfer the resulting cost figures to a cost accounting ledger without additional processing. A minimum amount of monthly entries are required due to the nature of the cost data presented on the computer printout, thus necessitating a small amount of clerical labor.

It should be noted that the computerized capability can be extended easily to the ledger segment of the cost system if a high volume file updating operation exists in a given NASA Center. Instead of maintaining a manual ledger, the record's essential features are built into the computer process. Nelson and Woods emphasize this basic point as they conclude that the objective of any set of accounting records, regardless of their form, is to permit periodic file updating from a given set of financial transactions.

> This rather elementary view of the nature of data processing holds for any level of clerical effort—manual, mechanical, tabulating, or electronic. In other words, the basic concept of what is done is unchanged by the nature of the personnel and equipment used to accomplish the result. Transaction files may consist of printed forms, punched cards, punched tapes, or magnetic tapes. Ledger, or balance files may consist of looseleaf pages, card files, tape reels, or magnetic discs.[12]

Figure 3-3 illustrates the essential features of the data processing function of the cost system. The value of the computerized processing capability is difficult to assess in quantitative terms, but on the basis of the trial period application of the system at ARAC, some interesting features should be mentioned. The total computer running times for the monthly cost performance processing and reporting were as follows:*

July	2 minutes and 16 seconds
August	2 minutes and 12 seconds
September	2 minutes and 34 seconds
Total	7 minutes and 2 seconds

Also, approximately 6 minutes of computer time were required for the weekly labor report so in about 13 minutes all of the relevant data for

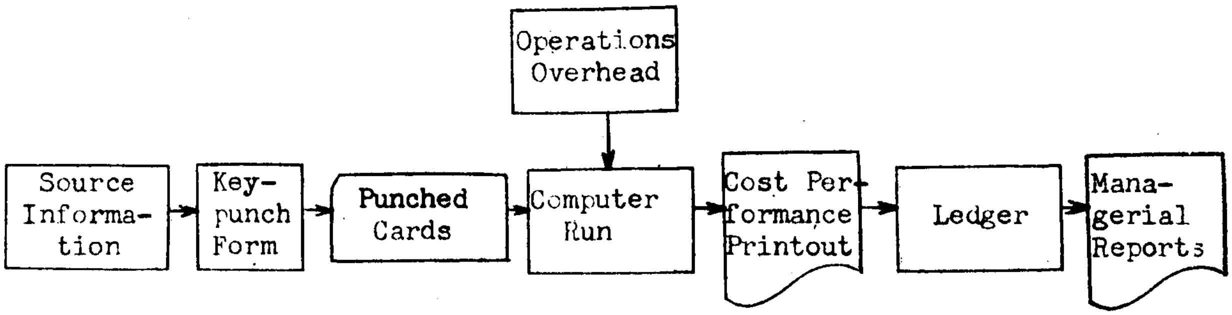
---

[12] Ibid., p. 524.

*The weekly labor and monthly cost performance reports both were printed during the specified running times.

Figure 3-3

Data Processing Function



the cost performance of the three month period were sorted, classified, and reported in the prescribed form. The total cost for the computer time necessary to process the data that accounted for 64 retrospective searches, 978 profile searches, and the other special services performed by the center was $46.15. The author's estimate of the clerical time that would have been required for the same output is 160 hours or $280.00 at a rate of $1.75 per hour. Keypunching charges for the three month period were about $18.00, and the other data processing functions required for the cost system (keypunch form preparation, recording, and reporting) were performed by a part-time clerk who worked eight hours per week and was paid $1.75 per hour, thus receiving wages of approximately $180.00 during the three months. Therefore, the total data processing costs of operating the cost system for three months amounted to only $244.15 or $81.38 per month.

Computerized Source Information Processing

A complete description of the procedures required for processing the source information is presented in Appendix I, and the purpose of this section is to summarize the essential features of the system. Computerized processing of the costs recorded during the production process on the source documents consists of three main phases: keypunching (recording), sorting (classifying), and summarizing (reporting). The source information is transferred manually from the source documents to the keypunch form shown in Appendix I, and is keypunched for computer processing with a coding system prescribed for the computer program. The coding system is illustrated and described in detail in Appendix I. The labor data are recorded on the keypunch form at the end of each week as a summary of the jobs reported on the daily time tickets. After the information is keypunched, a computer run generates a weekly printout which classifies the individual work increments performed by each employee in the various cost centers.

At the end of the month, the same procedures are performed for all the direct sundry expenses recorded during the period. A monthly computer run is performed to generate a printout that represents the total direct cost performance of the center during the period. Also, the proper operations overhead rate is calculated on the monthly report so the total production costs are included. Consequently, two essential reports, weekly labor performance and monthly cost performance, represent a continuous accounting of the production process of a NASA Center.

Weekly Labor Performance Report.[13] A three digit identification number is assigned to each employee with the first integer indicating the cost center in which the work is performed and the next two digits signifying the individual involved. The coding system is the same as that utilized in the preparation of the daily time tickets and is

[13]This report is defined for computer programming purposes as the Time Card Audit.

illustrated in Appendix I. The weekly computer printout identifies each employee by cost center and reports a complete listing of the work increments performed by the personnel during the week. The result is an itemized accounting of all information services performed during the period with labor hours, rather than costs, providing the unit of measurement. The managerial applications of the weekly report are described in the "Management Reporting" section of this chapter, and an abbreviated illustration is presented in Appendix I.

Monthly Cost Performance Report.[14] At the end of each month, the information collected on punched cards for the previous weekly labor performance reports is rerun on the computer by changing the program control code number to two instead of one. The computer will printout the final week's labor performance report and a monthly cost performance report during the same run. The objective of the latter report is to account for the production costs—direct labor, direct sundry expenses, and operations overhead—consumed for all information services during the month. Employee labor rates are established on control cards to convert the labor hours shown on the weekly reports to labor costs. Therefore, a different perspective for the labor element is presented on the monthly report from that of the weekly printout since the major classification is an itemized listing of all costs consumed for each information service or overhead account.

Another column is added to the monthly report to include a charge for the applied operations overhead. The predetermined overhead rate

[14]This report is defined for computer programming purposes as the Labor Cost Report.

selected from the normal capacity of a flexible budget is keypunched onto a control card as an input to the computer. The computer calculates the appropriate overhead charge for each job concurrently with the derivation of the direct labor costs. The direct sundry expenses (presented in physical quantities) recorded during the month also are keypunched on cards, using the same operating procedures as those employed for direct labor and a code number that signifies the specific cost item. Proper rates for each direct sundry expense element are keypunched on control cards, and the computer classifies the expenses by the related information service or overhead account. The result of the monthly computer run is a printout that reports all production costs, categorized by the individual cost increments. The monthly report provides the essential information for the manual postings to the cost accounting ledger and the derivation of several managerial reports. An abbreviated example of the monthly cost performance report is illustrated in Appendix I.

Cost Accounting Ledger

As is mentioned earlier, the decision was made to utilize a ledger file that requires a manual updating operation. Due to the nature of the cost data presented on the cost performance printout, a minimum amount of clerical work is necessary for the monthly posting function. The purpose of this section is to discuss briefly the essential features of the manual ledger employed in the cost system.[15] As is mentioned earlier,

---

[15]A variety of forms and contents are available for a cost accounting ledger, and the reader is referred to the following textbook for a detailed description: Adolph Matz, Othel J. Curry, and George W. Frank, op. cit. Also, we assume for illustrative purposes that the only accounting record employed for entry to the cost accounting ledger is the monthly cost performance printout. In practice, however, a formal cost accounting journal also may be utilized to supplement the computer printout.

essentially the same principles are applicable if a center decides the required clerical labor volume warrants computerizing the ledger files since the basic characteristics of a manual ledger can be set up on a tape reel or magnetic disc.

An essential feature of a successful accounting system is a well defined chart of accounts which provides the mechanism for an accurate recording of the essential financial and operational transactions of a NASA Center. Kean defines a chart of accounts as:

> a uniform, systematic listing of assets, liabilities, capital, income, and expenses in a logical order, giving account names and numbers so that accurate financial statements may be extracted and prepared in the sequence that they will be shown on the balance sheet and statement of profit and loss.[16]

As is mentioned in the beginning of this chapter, the accounts of the proposed cost system are assumed to be controlled by and subsidiary to the general financial accounting system of a NASA Center. The chart of accounts thus serves as the linkage between a center's financial and cost accounting system, and the relationship between the two is illustrated in the chart of accounts shown in Exhibit IX which was used for the trial operation of the system at ARAC. Since the purpose of this study is cost accounting oriented, we concentrate our discussion on the essential features of the expense segment of the chart of accounts. Matz, et. al. suggest that the following considerations are essential in the design of a realistic set of accounts:

---

[16]Milton J. Kean, "Some Suggestions for Preparing a Chart and Manual of Accounts," N.A.C.A. Bulletin, XXXVII (April, 1956), p. 1002.

1. Accounts should be arranged and designated to give maximum information with the least need for supplementary analysis consistent with a reasonable degree of economy in performing the accounting function.

2. Account titles should reflect as far as possible the purpose rather than the nature of the expenditure.

3. Manufacturing, distribution, and administrative cost accounts should receive particular attention as these accounts are used to bring efficiency variations to management's attention.[17]

The responsibility accounting framework of a NASA Center should be incorporated into the chart of accounts, and a numerical coding system should identify readily specific accounts with the related cost center as well as the expense element. The dual relationship of the accounts facilitates the dual objective of performing responsibility accounting and service costing concurrently. In the chart of accounts employed for the three month period at ARAC, a four digit number was used for each expense account. The first two digits identified the cost center in which the expense was incurred, and the last two integers denoted the specific cost item involved. For example, account number 7010 signifies the following information:

70	Engineering Section Cost Center
10	Engineering Labor Cost

The ledger represents a summary record of every account established in the chart of accounts. As current financial transactions take place during the production process, the ledger files must be updated accordingly. The monthly cost performance printout provides an efficient channel to the ledger for the cost accounting process since the computer

[17]Adolph Matz, Othel J. Curry, and George W. Frank, op. cit., p. 37.

printout classifies the cost data recorded on the source documents by the account to which they should be charged. The major clerical element required in the cost system is the manual transfer of the reported costs on the monthly printout to the ledger accounts to update the permanent cost records. The ledger contains a perpetual record of the cost accounting history of a center and provides a source of the information required for managerial reporting.

Managerial Reporting

Managerial reports represent the results of the interaction of the cost system components described in the preceding sections. The processed cost data must be assembled and presented in a meaningful manner before genuine managerial information is available. The overall objective of the reporting procedure is to generate relevant and timely information that will aid management in the planning, controlling, and decision-making functions. In this section, we identify several reports that should be applicable to a NASA Center for a quantitative measurement of the operating performance.

1. Financial Statements

   The balance sheet and income statement should be issued monthly to inform management of the financial operating condition of a center. A balance sheet represents a statement of the financial position of the organization as of a given date, thus depicting a cumulative report of all the accounting transactions recorded since an operation was initiated. The income statement shows how a center has progressed financially during a specific operating period. A comparison of the appropriate share of revenue and operating costs, service and nonservice, is reported. Both of the financial statements are illustrated in Exhibit X.

2. Labor Performance Report

The weekly computer printout described in the previous section represents a labor performance report and is illustrated in Appendix I. The historical labor information should aid management in evaluating the productivity of the employees since their actual performance is summarized. Also, the report shows the amount of productive time performed as direct labor in relation to the total payroll. The comparison should be valuable in planning required manpower levels and then measuring the actual versus planned labor utilization. The summary section of the report also should be conducive toward the planning function since it shows the total labor hours, by employee classification, expended for each information service category. The information should facilitate future manpower planning and scheduling by providing an estimate of the labor necessary for expected service activity levels.

3. Monthly Cost Performance Report

The monthly computer printout discussed in the previous section represents an analysis of the costs consumed during the information search process for the different services. Responsibility accounting also is facilitated as the cost increments are identified with the cost centers in which they are incurred. The percentage breakdown of the cost elements of each information service should contribute toward effective planning and controlling functions. Thus, the report not only is useful for file updating of the different ledger accounts, but also presents relevant information for a managerial evaluation of the financial operating performance of a NASA Center. An abbreviated example of the monthly cost performance report is illustrated in Appendix I.

4. Cost Center Performance Report

Exhibit XI illustrates a monthly cost center report which compares the budgeted and actual expenses for a particular responsibility unit. Since the objective of a NASA Center is to operate at a breakeven revenue level, any deviation from the planned cost performance, upon which prices are based, must be identified immediately for corrective action. The cost center report presents regular information for this objective by relating the cost performance comparison to the responsible manager.

5. Service Cost Report

The purpose of this report, illustrated in Exhibit XII, is to list the production cost increments recorded for each information service completed during a month. Itemized detail of the direct labor, direct sundry expenses, and operations overhead is presented for each unit. The report provides management with essential information for an evaluation of the feasibility of the current price schedule. The unit cost data also are valuable for planning and controlling the production performance.

6. Revenue - Cost Report

Another important comparison is that of the costs expended for the different information services performed for each client and the revenue generated from the products. The report provides a periodic review of the costs versus the benefits of serving each customer and should contribute valuable information for future pricing. An example of the report is presented in Exhibit XIII.

7. Overhead Analysis Report

The purpose of the overhead analysis report is to identify the causes of any deviation between actual and applied operations overhead. As is mentioned earlier, a predetermined rate is applied to an activity basis such as direct labor costs for the distribution of the operations overhead to the information services. The difference between the actual indirect costs consumed and those applied can be divided into a budget variance and a volume variance. The budget portion of the overhead variance is calculated by comparing the budgeted costs at the attained activity level (referred to as the adjusted budget level) with the actual overhead incurred during the period. A volume variance is calculated by subtracting the applied overhead from the budgeted figure at the attained activity level. The variances provide useful managerial information since unfavorable deviations signal a need to determine exact causes of the actual overhead costs exceeding those budgeted or the actual volume terminating at a lower level than the predetermined normal capacity. These features are illustrated in the example presented in Exhibit XIV.

COST BEHAVIOR-PRICING POLICY

Fixed Cost Factor

The sizable fixed cost element of a NASA Center complicates the calculation of a realistic price schedule for the information services. The primary reason for the problem is the nature of the work force required for the literature searching process. In a typical manufacturing company, direct labor represents a variable cost since the number of workers is increased or decreased to coincide with changes in production activity. Certain seniority agreements with labor unions may create exceptions to the policy, but in general the direct labor-variable cost correlation prevails.

Also, the amount of equipment available normally determines an operation's capacity in today's automated business world. The direct labor element required for given machinery utilization levels is maintained, and as production activity varies, the work force is adjusted proportionately. However, due to the nature of the work activity, the capacity of an information center is regulated primarily by the number of technical employees available. As is mentioned earlier, the engineers possess specialized education and training so they are not the type of workers that can be hired and discharged or laid off frequently. Consequently, an information center cannot vary these salaries in proportion to service volume. The problem is magnified by the fact that the salaries normally are high cost items due to the required skills and scarcity of information specialists.

The term "fixed cost" represents a misnomer for the technical labor if one adheres to its true definition which implies that the cost cannot be changed. Instead, different categories of fixed costs exist, depending on the length of time a cost remains constant or the range of activity over which the fixed factor persists.[18] For example, management of a NASA Center can alter the number of technical personnel if allowed sufficient lead time. The assumption is made earlier that a yearly period is required for this objective since an annual interval coincides with a center's planning process (for example, the budgeting cycle) and offers management sufficient time to evaluate such factors as expected labor turnover, available prospective personnel, the competence of the existing staff, and required manpower levels for the forecast service activity. Consequently, the annual planning phase represents the only material opportunity for staff level adjustment. Costs such as the engineering labor are referred to as discretionary costs, a term that Shillinglaw defines as:

> Costs which have no cause-and-effect relationships to current volume but are fixed by management decisions, usually when operating plans are approved.[19]

The direct labor costs (variable or fixed) do not create any significant unit costing problem since they are traced to specific information services during the production process. However, the remaining portion of the discretionary labor causes a major problem in the derivation of reliable unit costs since these expenses are recorded as indirect labor and charged to operations overhead. The total engineering labor

---

[18]Gordon Shillinglaw, Cost Accounting - Analysis and Control (Rev. ed.; Homewood, Illinois: Richard D. Irwin, Inc., 1967), p. 61.

[19]Ibid.

cost of a NASA Center remains relatively fixed over various activity levels so a different unit service cost is calculated for each volume. As a result, the critical question is: "What is the correct activity level for the derivation of unit costs that at least will serve as a guide for realistic information service prices?" While most business firms are concerned with the same problem, the issue is amplified in an information center due to the large discretionary cost element.

Pricing Policy

The calculation of reliable unit service costs is fundamental to the establishment of an objective pricing policy. Pricing the information services is a critical phase of managing a NASA Regional Dissemination Center since the objective is to operate as a non-profit, self-supporting entity. Short run deviations from random error may cause small operating profits or losses, but the total costs and revenues should be equal in the long run. Since the centers lack a profit objective, a theoretical pricing model based on an optimizing technique is not applicable. For example, economic theorists advocate that the appropriate price for each product is that which equates the item's marginal revenue and marginal cost.[20] Marginal revenue is defined as the increase in total revenue resulting from the sale of one additional product while marginal cost represents the addition to the total cost that results from increasing the volume by one unit. It can be proven mathematically that the price which equates marginal revenue and marginal cost assures a firm of

---

[20]Richard H. Leftwich, The Price System and Resource Allocation (Rev. ed.; New York: Holt, Rinehart, and Winston, 1963), p. 206.

maximum profits from a given product. However, even profit-seeking business firms find this concept difficult to adopt, and Anthony suggests that certain information limitations hinder the application of the optimizing model and force management to rely on a full-cost pricing policy. He summarizes the argument as follows:

> Who can estimate what quantities of product will be sold at one price, let alone at all possible prices. Indeed, the difficulty is so great that few companies ever attempt to estimate a demand schedule and few managers have even seen one.[21]

Anthony discusses the basis for a full-cost pricing policy in the following way:

> Note that the relevant costs are full costs, which are the direct costs plus a fair share of allocated costs; they are not the differential costs discussed in the preceding section. The result of this calculation is a first approximation to the price; it is modified to take into account the strength of competition, the necessity of fitting the price into customary price lines (such as $9.98 dresses), and many other marketing considerations.[22]

Once again, the sizable fixed cost element of a technical information center requires careful consideration for a full-cost pricing policy The full-cost approach implies that the recorded direct production costs, the related share of operations overhead, and a portion of the selling and administrative expenses must be included. Yet, such reasoning may lead one into a circular-reasoning problem due to the necessary distribution of the fixed costs. Horngren explains the phenomenon as follows:

---

[21]Robert N. Anthony, op. cit., p. 575.

[22]Ibid., p. 576.

> Many businessmen maintain that they use cost-plus pricing. They say that they figure their average unit costs and tack on a "fair" margin that will yield an adequate return on investment. This entails circular reasoning, because price which influences sales, depends on full cost, which in turn is partly determined by the volume of sales.[23]

So, the critical feature in the distribution of the fixed costs is the interaction of price and volume. If consumer demand for the information services is price elastic (sensitive to price changes), management can expect varying levels of demand, depending on the chosen price level. However, from a practical viewpoint, an accurate prediction of such customer reaction appears highly unrealistic, as is mentioned by Anthony. The problem is especially acute in the operation of a technical information center due to such factors as the relative newness of the technique of scientific information retrieval, the lack of competition, and the uncertainty of a client's utility from the information. For example, it appears likely that a client will be willing to pay a substantial sum if he is assured a correct answer to a problem that otherwise would require a research project. However, the same customer probably would not pay as much for information selected as relevant if uncertainty concerning its utility prevails.

The price a client is willing to pay is more likely a function of the probability of receiving reliable information and the seriousness of a given problem than the established charge for a search. Consequently, the unique nature of a technical information center's products and the vagueness associated with their utility appear to justify an assumption

---

[23]Charles T. Horngren, op. cit., p. 318.

that demand for the services is price inelastic (within a comparatively wide price range). The circular-reasoning argument against full-cost pricing is not significant if inelastic demand prevails since the consumers purchase approximately the same amount of services, regardless of relatively wide price adjustments.

Additional support for full-cost pricing in a NASA Center is attained from the following discussion by Moore and Jaedicke:

> The full cost price has been referred to as a "safe" price. Perhaps there is a greater desire to prevent large losses than to achieve maximum profits. Also, it is true that all costs must be covered in the long run if the firm is to survive.[24]

This type of reasoning is especially relevant for a NASA Regional Dissemination Center due to its breakeven objective. Profit is not even a pertinent consideration, and the primary concern is minimizing the probability of an operating deficit since the centers usually do not have past years' earnings with which to absorb a loss. Instead, costs must be estimated accurately for each operating period and matched with a sufficient amount of revenue. This approach implies that all operating costs are included as a basis for price determination. Although a full-cost pricing policy does not guarantee that the desired objective will be accomplished, if used correctly it should assure a high probability of success.

As is mentioned earlier, the estimation of a reliable activity level to use in allocating the indirect costs is the most essential phase

---

[24]Carl L. Moore and Robert K. Jaedicke, Managerial Accounting (2nd ed.; Cincinnati, Ohio: South-Western Publishing Co., 1967), p. 572.

of a full-cost pricing policy. The direct production costs (direct labor and direct sundry expenses) are included in the unit costs as they are traced to the individual services. Operations overhead, representing the indirect production costs, is applied to the products on the basis of a predetermined rate so a fair share is contained in the unit service cost. If a portion of the selling and administrative expenses is added to the unit cost generated via the cost accounting system, a full-cost basis will be achieved. However, many of the indirect expenses are fixed during an operating period so different activity levels produce varying unit costs. If the assessment of an activity level is incorrect, a variance will result between the prices charged and the actual service costs since the fixed costs are averaged over an incorrect volume. Since normal capacity is suggested as the most realistic estimate of consumer demand for operations overhead allocation, the same philosophy should prevail for the distribution of the selling and administrative expenses. Therefore, all indirect costs, service and nonservice, are allocated in proportion to the direct labor costs required to produce the services. An example of a full-cost pricing model which is developed in more detail in later chapters is shown in Figure 3-4.

Figure 3-4

Full-Cost Pricing of Information Services

$$\text{Average Unit Service Cost} + \left[\frac{\text{Budgeted Selling and Administrative Expenses @ Normal Capacity}}{\text{Direct Labor Costs @ Normal Capacity}} \times \text{Average Direct Labor Cost Per Unit}\right]$$

Since a NASA Center will require a price to quote to its clientele, a representative value must be selected from the historical cost data. The mean (arithmetic average) presents an accurate measure of the central tendency of most frequency distributions so it is hypothesized to be the most realistic basis for a unit service price. Specific procedures for determining the average unit costs of a retrospective search and a profile search are considered in Chapter 4 and 5, respectively. The full-cost pricing policy is combined with statistical sampling theory for the derivation of the average service costs.

COST DATA RELIABILITY

Representative Figures

The nature of the information services restricts the derivation of realistic standard costs which consist of a predetermined relationship between production inputs and outputs. The intervening variables discussed earlier influence the cost of an information search, thus causing cost deviations that normally are beyond the control of the operating personnel. Consequently, if a standard cost system is employed, unfavorable variances will arise regularly since the uncertainty concerning the mix of intervening variables for an individual service request cannot be incorporated realistically with the cost data. A center does need cost targets to utilize as typical figures, however, for planning, controlling, and decision-making. The cost system generates a mass of data that must be condensed into a set of representative values. For example, several retrospective searches may be performed at varying unit costs during a given period and the array of figures can be plotted as a frequency distribution which indicates the number of occurrences for the different unit costs. While the total information is beneficial to management, a numerical measure is required to condense the distribution into a representative figure which will serve as a cost target.

The arithmetic mean provides an effective device since it represents a measure of a distribution's central tendency. As long as a distribution does not contain numerous extreme values (measured as a departure from symmetry), the mean depicts an accurate numerical measure of the entire array of data. Average service costs are hypothesized to be the most realistic figures for cost target determination due to their computational ease and representative character. Specific applications of the mean data are shown in costing the Retrospective Search Service and the Selective Dissemination Service in Chapters 4 and 5, respectively. Also, the cost means are essential in the statistical cost system presented in Chapter 6.

Reliability Measure

Since the average costs are extremely important for managerial applications of the cost data, they should be reliable figures that do not vary substantially between periods. If the means deviate materially, their usefulness as representative figures is marginal. However, if the cost system functions effectively and the distribution of the multi-dimensional intervening variables affecting the unit search cost is approximately the same from month to month, it is hypothesized that the monthly average search costs will be comparatively equal, subject only to random error. The equal distribution assumption refers to the fact that roughly the same average mix of the intervening variables prevails each month when balanced out over the entire array of service units. Otherwise, the unit cost distribution could shift to the right or left as a function of these uncontrollable variables, thus causing the mean costs to shift also. In such cases, the cost targets must be revised accordingly so the fact that unequal monthly means exist should be revealed to management.

Analysis of Variance

An analysis of variance model provides an efficient statistical technique to test the hypothesis that the average search costs are approximately equal from month to month. Duncan defines an analysis of variance model as follows:

> One of the most powerful tools of statistical analysis is what is known as "analysis of variance." Basically it consists of classifying and cross-classifying statistical results and testing whether the means of a specified classification differ significantly.[25]

The technique is based on the premise that the variance of a universe of data should be greater than subgroup variances within the total if the means of the separate groups are not equal. Consequently, the total variance of the overall mean of a series of data is divided into parts related to specific sources which are of experimental interest. Since the only critical factor in the cost data analysis is the relationship of various average costs, a one way, fixed effects model provides a sufficient amount of detail, and all other variables are held constant in this study. The term "one way" refers to the fact that only one

---

[25]Acheson J. Duncan, Quality Control and Industrial Statistics (3rd ed.; Homewood, Illinois: Richard D. Irwin, Inc., 1965), p. 549.

dimension, average cost comparisons, is analyzed while "fixed effects" means that sampling is achieved from a population consisting of all the items of experimental interest.

The assumptions underlying an appropriate application of the model are the following:

1. We have k random samples from k populations.
2. The k population variances are equal.
3. The k populations are normally distributed.[26]

The service cost data should be analyzed carefully in specific cases to insure that these conditions exist.

Model Components

In order to classify the cost data, the components of a one way, fixed effects model are summarized in the following mathematical identity:

$$X_{ij} = \bar{X} + (\bar{X}_j - \bar{X}) + (X_{ij} - \bar{X}_j) \tag{1}$$

Where:

i = the number of sample observations taken from a given month's cost data.

j = the number of months in question.

X_{ij} = ith sample observation from the jth month.

$\bar{X}$ = estimate of the overall mean.

$\bar{X}_j$ = estimate of the mean of the data from the jth month.

Independent, random samples are drawn from the service cost data pertaining to each month under observation. An estimate of the overall mean and one pertaining to each month are calculated from the samples.

[26] William C. Guenther, Concepts of Statistical Inference (New York: McGraw-Hill Book Company, 1965), p. 203.

Figure 3-5 shows a schematic illustration of the procedure for a three month period:

Figure 3-5

Sampled Service Cost Data

	Month			
	July	August	September	Overall
	X_{11}	X_{12}	X_{13}	
	X_{21}	X_{22}	X_{23}	
	X_{31}	X_{32}	X_{33}	
	⋮	⋮	⋮	
	X_{n1}	X_{n2}	X_{n3}	
Totals	T_1	T_2	T_3	T
Means	$\bar{X}_1$	$\bar{X}_2$	$\bar{X}_3$	$\bar{X}$
Variances	s_1	s_2	s_3	s

X_{ij} = the sample observation in the ith row and jth column

Columns range from 1 to 3. (k=3)

Rows range from 1 to n.

Total observations are N.

Testing Procedure

The essence of the model shown in (1) is that each X_{ij} sample observation (unit search cost) is divided into the following three parts to test the hypothesis that the monthly mean costs are equal:

1. Overall mean.
2. Between groups variance—the difference between each sample mean and the overall mean.
3. Random disturbance term or within groups variance—the difference between each sample observation and the related column mean.

The between groups variance must be approximately zero if the hypothesis that the monthly mean costs are equal is true. The only variability within the columns must be a function of random error since the expected value of each observation is equal to its column mean. However, variability in the between groups variance can evolve from either random error or the fact that the hypothesis is false. If the hypothesis is true, the ratio of the between groups variance and the within groups variance should be approximately one or less since all disturbances result from random error. The variances divided by their respective degrees of freedom (k-1, N-k) are referred to as the mean square-between groups and the mean square-within groups. It can be shown that the ratio of the two is distributed as an "F" distribution, which is the ratio of two Chi-Square distributions divided by their respective degrees of freedom. Several significant values of the "F" distribution are tabled in most statistical text books.

A significance level, representing the probability of rejecting a true hypothesis, is selected and a test is performed to compare the mean square-between groups and the mean square-within groups. The value calculated from this ratio is compared with the critical value derived from an "F" distribution table for a given significance level and a particular pair of degrees of freedom. If the calculated value is less than that shown in the table, the hypothesis is accepted, and the monthly average search costs are considered approximately equal, subject only to random error. Otherwise, the hypothesis is rejected, and further investigation is required to determine the cause of the differences. The results of the application of the analysis of variance model to the cost data from the trial period at the Aerospace Research Applications Center are revealed in Exhibit III.

CHAPTER 4

COSTING A RETROSPECTIVE SEARCH SERVICE

SERVICE DESCRIPTION

Basic Objective

In this chapter, the basic managerial cost accounting concepts developed in Chapter 3 are applied to the first of the two main services performed by a NASA Regional Dissemination Center, the Retrospective Search Service (RSS). Since a specific set of operating procedures is required to exemplify a realistic production process, the methods utilized by the Aerospace Research Applications Center (ARAC) are employed. Other NASA Centers may deviate from these procedures due to specific operating conditions, but the essential features of the proposed cost system are applicable to all centers.

The Retrospective Search Service is designed to enable a client to identify documents relevant to a specific problem. An exhaustive search of the index to literature available to a NASA Center is performed by an engineer to accomplish this objective. Each search is assigned to a staff member whose training and experience are compatible with the particular problem. The primary search is accomplished through computer methods since the NASA information file (An index of the documents listed in Scientific and Technical Aerospace Reports and International Aerospace Abstracts) is stored on magnetic tape. The engineer constructs a search strategy to match a problem with the descriptors used to classify the scientific and technical reports in the NASA file. The computer identifies the information citations related to the search strategy, and the engineer determines if they contain relevant information.

If a sufficient number of appropriate reports are not located by the computer search, the engineer also may perform a manual search of other potentially relevant information sources.

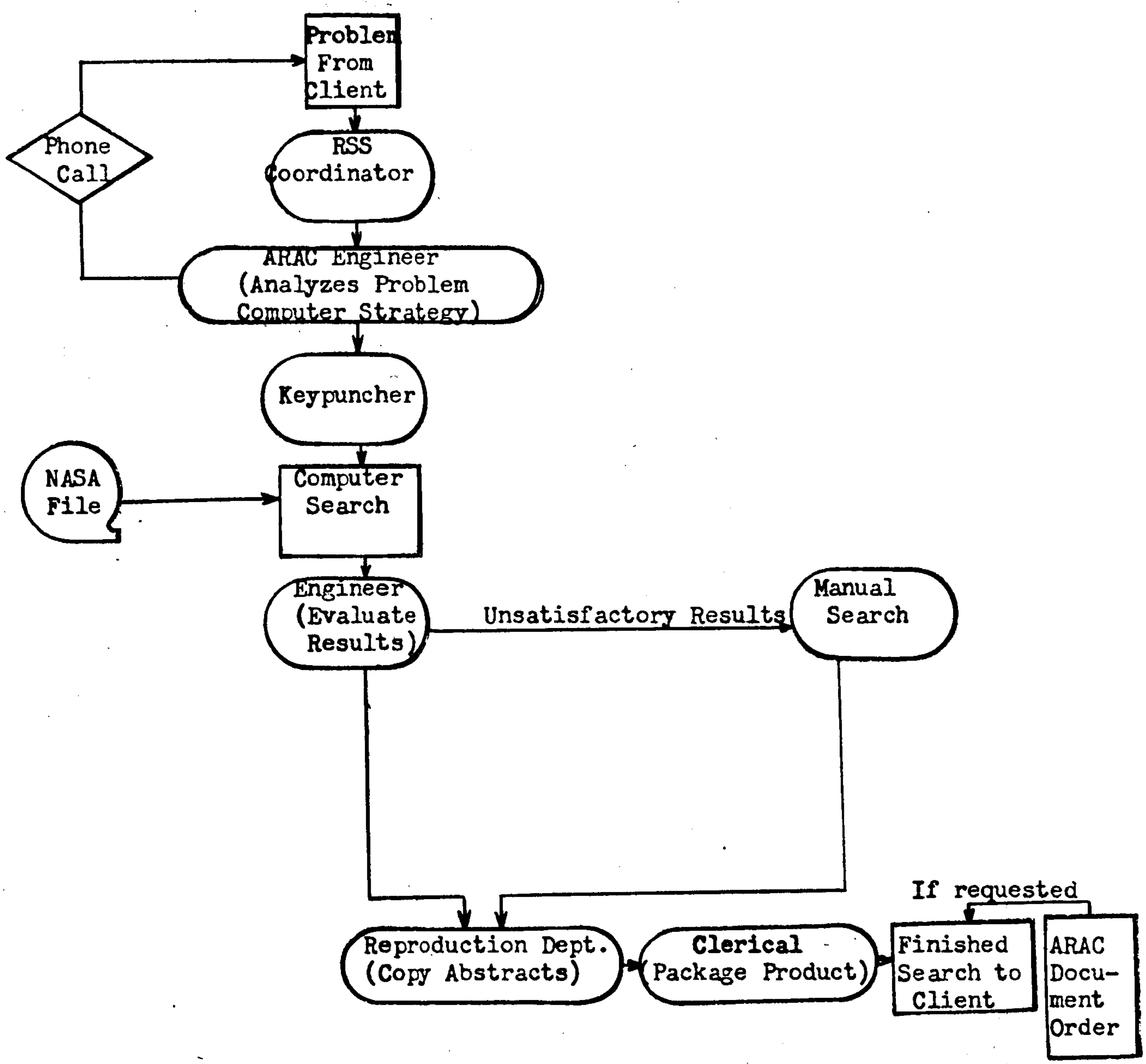
RSS Work Increments

The set of operating procedures utilized by ARAC for the retrospective search process is illustrated in the work-flow chart shown in Figure 4-1. The RSS process is initiated when a client requests relevant information for a well-defined problem by submitting the subject to ARAC. The RSS coordinator analyzes the request and assigns it to an appropriate engineer who studies the problem and then contacts the client (usually by telephone) to insure that all pertinent aspects of the query are understood. Next, he constructs a search strategy by selecting and relating the terms which may have been used to classify the relevant documents in the NASA file. The selected terms are keypunched on punched cards and matched by an electronic computer against the information stored on magnetic tape. The result of the process is a printout of the accession numbers of the potentially relevant documents identified by the computer.

The engineer's next step is to match each accession number shown on the computer printout with an abstract of the identified information. An abstract of each document in the NASA file is provided in periodical and index card form. The engineer edits those abstracts related to the computer printout to determine if the reports contain relevant information for the given problem. The result of the editing process is a subset of abstracts of the reports that the engineer believes contain information which is most relevant from the total identified by the computer. If

Figure 4-1

ARAC RSS Work Flow



these reports comprise sufficient information to satisfy the client's request, the search process is finished. However, if the engineer decides that an insufficient number of reports have been discovered, he performs a manual search of other information sources.

The final product of the search process is a set of abstracts which summarizes the content of the documents chosen as relevant to the client's problem. The selected abstracts are reproduced and packaged for mailing to the client. Clerical and other nonengineering labor is required for these functions as well as several other miscellaneous stages of the production process. If the client chooses to order the documents abstracted, clerical work also is necessary for the document ordering function.

RSS COSTING METHOD

General Description

The costing method suggested for the Retrospective Search Service essentially is a job order system. Each retrospective search represents an identifiable job which requires distinguishable cost elements as it passes through the production process. Therefore, every search is assigned a job number when it is initiated and is treated as a heterogeneous unit. Vance characterizes a job order costing method as follows:

> Job order costing is used where the cost of separate jobs is wanted. Jobs are kept separate and their costs separately compiled where the materials and work done vary from job to job, and especially where several different jobs may be worked on at the same time. The important condition for use of job order costs is that individual jobs be separately identified in the operating departments. This may be done even where the product is uniform, but the method is used mostly by concerns which make a variety of assembled products.[1]

The production costs traceable to a given search are charged directly to the related job number and accumulated monthly on a job order cost

---

[1] Lawrence Vance, Theory and Techniques of Cost Accounting (Rev. ed.; New York: Henry Holt and Company, 1958), p. 23.

sheet. This master sheet, illustrated in Exhibit XV, is designed to collect all direct labor, direct sundry expenses, and operations overhead assigned to individual retrospective searches. As the direct cost increments associated with the stages of the production process illustrated in Figure 4-1 are incurred, they are registered by job number on various source documents and processed through the electronic data processing function. The indirect charges (operations overhead) are distributed by the application of the predetermined overhead rate to the direct labor costs calculated by the computer for each search. Consequently, the three elements of service cost—direct labor, direct sundry expenses, and operations overhead—are recognized. The job order cost sheet provides a perpetual record of all expenses reported for a search on the monthly cost performance computer printout. The total costs recorded for the searches being performed are accumulated in the RSS in Process account in the ledger system until a retrospective search is completed and mailed to the customer. After the search is sent to the client, the job order cost sheet indicates the amount which must be transferred to the Finished RSS account and shown on the period income statement.

Minor Exceptions

The essential feature of a job order costing method is that the individual service units are distinguishable when the costs are consumed during the production process. However, certain labor and computer costs are traceable directly to the Retrospective Search Service but not to individual searches. Such expenses are necessary for a center to operate the RSS system so a misallocation to the other services would arise if the costs are considered operations overhead. It is hypothesized that a slight deviation from a rigid definition of job order costing must be employed to calculate realistic retrospective search costs. Labor costs in this category should be classified as general RSS in proportion to the amount of time recorded on the daily time tickets. The labor costs are incurred to insure that the RSS system is functional so they should be batched and averaged over the searches performed during a monthly period since these units benefit indirectly from the expenditures. Consequently, an element of RSS costing which is parallel to the technique used in process costing is employed. The computer maintenance time required to update the information file is another cost item that benefits the overall RSS system and is accounted for similarly in a later section.

Any labor element which is a direct cost to the RSS system but cannot be identified with specific searches is recorded as general RSS labor on the daily time ticket and classified accordingly by the computer. The portion of general RSS labor distributed to each search is calculated from the monthly cost performance printout and registered on the job order cost sheets. An example of the direct labor traceable to the Retrospective Search Service is a segment of the salary of ARAC's RSS coordinator. A substantial portion of the RSS coordinator's job is concerned with administering the collective service effort to insure that the system functions efficiently and the searches are available to the clients on schedule. Also, certain nonengineering work is required to provide control checks on the current status of each search performed by the center as well as accomplish routine clerical tasks which are not traceable to individual jobs. Although the portion of total labor costs classified as general RSS labor is small, these expenditures must be included in the unit search costs for realistic measurement.

RSS COST FLOW

General Concept

In the previous two sections, the work flow of an RSS system and the basic costing technique proposed for the service are presented. The purpose of this section is to integrate both concepts by accounting for the RSS production cost elements—direct labor, direct sundry expenses, and operations overhead—related to the performance of a typical search. The cost accounting system collects the data necessary to determine the costs attached to the individual stages of the RSS work flow shown in Figure 4-1. A job number is assigned to each retrospective search, and a job order cost sheet furnishes a complete record of the following cost elements charged to the project during the manufacturing operation and reported via the computerized data processing function.

Direct Labor

Each worker records the time expended for individual retrospective searches on a daily labor time ticket (See Exhibit IV). The work increments shown in Figure 4-1 are registered to generate a collection of the total RSS labor consumed in the cost centers. The following stages of the production process are reported on the time sheets:

1. Engineering

   a. RSS coordinator's time spent on individual searches.

   b. Analysis of the problem.

   c. Discussion of the problem with the client.

   d. Preparation of a computer strategy.

   e. Edit of the computer printout.

f. Manual search if necessary.

g. Selecting the relevant abstracts.

2. Nonengineering

a. Clerical work.

b. Reproduction labor.

c. Keypunching.

d. Computer operation.

e. Packaging the final product.

The different functions normally are performed during a two-week period so the total labor for each job is distributed over numerous daily time tickets. The information is collected monthly and recorded on the appropriate job order cost sheet. The electronic data processing procedure which classifies and reports the diverse labor source information is discussed later in this chapter.

Direct Sundry Expenses

The three major recurring direct sundry expenses of the Retrospective Search Service are: (1) telephone calls; (2) computer expenses; (3) reproduction charges. Once again, these items are charged to the related job number as they are incurred. When the engineer telephones the client to clarify the details of the information request, an entry is made in a telephone record to register the related RSS number, date, engineer, and client. Since lengthy telephone calls often are required to insure complete understanding of the problem, the treatment of the calls as direct costs is essential. The telephone cost data are transferred monthly from the telephone record to punched cards, processed via the computer, and registered on the related job order cost sheet.

The computer operating time is recorded and classified as the proper work activity code by the machine during each run. A dichotomy between the direct computer time incurred in the information searching process and the maintenance time required to update the file is maintained for the total RSS computer costs. The nature of the RSS computer time is identified for each run, and the program presented in Appendix II is employed to instruct the machine to record the appropriate service code concurrently with the job performance. At the end of each month, a printout is generated that reports a classified listing of the computer costs utilized in the RSS system. The proper computer rate is included on a punched card to convert the physical quantities into cost figures.

Another slight departure from a strict definition of job order costing arises due to the nature of the computer searching time. A batching technique is required to distribute the computer time to individual searches since the direct computer time usually is traceable only to several retrospective searches. Normally, numerous searches are performed during a single computer run to take advantage of the machine's ample capacity so the identification of the time segment required for a specific search is impossible.

Since the number of searches performed during each computer run varies from time to time according to consumer demand, an inequitable cost distribution would develop if the total time per run is allocated to the related searches. This relationship is amplified by the fact that the time required for a given computer run is relatively insensitive to the number of searches performed. For example, if the total running time for five searches is thirty minutes at $300 per hour, the average cost per search is $30. Due to a computer's fast searching capability, essentially the same amount of time would be required for ten searches, thus creating an average cost per search of $15. If the actual computer costs are distributed over the related searches, wide variations in unit search costs will result as a function of the number of searches per run rather than the time required for individual jobs. Consequently, it is hypothesized that an objective method with which to overcome the problem is to batch the total direct computer time incurred in the search process during a monthly period and average the costs over the related retrospective searches. The averaging procedure eliminates the wide variations in unit costs that otherwise might exist.

The maintenance computer time required to update the information file is distributed to the searches through the application of a model presented in a later section. Thus, both types of computer time necessary in the RSS system, direct and maintenance, are charged to service units. The total computer costs assigned to each retrospective search are recorded monthly on the job order cost sheet via the data processing function discussed in the following section.

Reproduction costs are registered on the work order form shown in Exhibit V. When an engineer requests copying work from the reproduction department, he initiates a work order by recording the proper RSS number and nature of the task. The personnel performing the work use the form to record the type of equipment and operating supplies utilized in the reproduction process. At the end of each month, the reproduction costs per search are accumulated and processed by the computer for entry to the job order cost sheet.

Operations Overhead

The applied operations overhead rate selected from the normal capacity of a flexible budget is recorded on a punched card for the electronic data processing function. The procedures used to determine a realistic overhead rate from a flexible budget are discussed in Chapter 3. The selected rate is applied to the total direct labor costs consumed in the production of individual retrospective searches by the computer and a complete listing of the applied monthly overhead is listed on the cost performance printout. At the end of an annual period, any variation between the applied operations overhead and the amount actually incurred during the production process must be reconciled. An overapplication must be credited to the cost of services while an underabsorption must be charged to the cost of services.

Summary

As the work increments of the Retrospective Search Service illustrated in Figure 4-1 are performed, the direct service costs are recorded on various source documents. The source information is processed and registered on the appropriate job order cost sheet, one of which is established for each search. The labor traceable to individual searches is charged to the correct job numbers on the daily time ticket, and the work performed for the overall RSS system rather than specific searches is accumulated in one classification, general RSS, and averaged over the number of jobs benefiting from the cost. All direct sundry expenses are recorded on the appropriate source documents and transferred to the job order cost sheet via the electronic data processing function. Operations overhead is applied by the computer on the basis of the predetermined overhead rate derived from the annual flexible budget. The summation of the direct and indirect charges on each job order cost sheet reflects the total unit RSS cost.

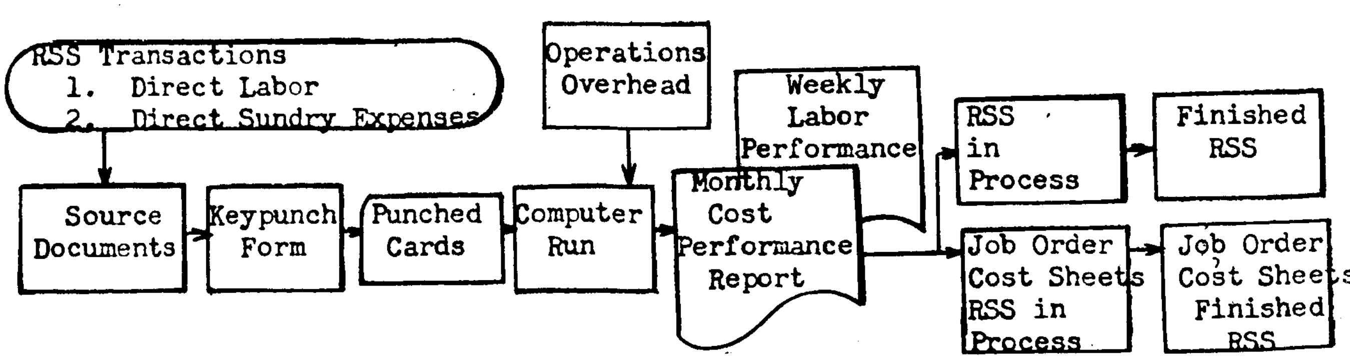
DATA PROCESSING FUNCTION

General Scope

The data collected during the production of retrospective searches must be sorted and processed by job order number for the determination of the unit costs. Since each search is considered a heterogeneous unit, the objective of the data processing function is to present the total costs associated, either directly or indirectly, with a search during the production process on a job order cost sheet. The computer procedures discussed in Chapter 3 provide the transition from the source information to the job order form. The essential features of the flow of RSS cost information through the cost accounting system are shown in Figure 4-2, below.

Figure 4-2

RSS Cost Accounting Flow



Computerized Processing

The RSS labor recorded on the daily time tickets is transferred at the end of each week to the keypunch form shown in Appendix I. After the information is keypunched and sorted, a computer run generates a printout in the form of a labor performance report which presents a listing of the time expended by each staff member on individual searches as well as the general RSS category. At the end of the month, the direct sundry expenses also are collected from the various source documents (classified by job number) and keypunched for computerized processing. The monthly cost performance printout shows all costs collected during the period for each retrospective search performed and the general RSS labor effort. The coding system indicates the nature of each RSS expense item reported on the printout. An abbreviated example of the RSS segment of a typical cost performance printout is shown in Figure 4-3 to illustrate how costs are reported for an individual retrospective search.

Figure 4-3

RSS Cost Performance Reporting

Job	Section (Cost Center)	Man	Hours (Quantity)	Base Cost	Operations Overhead	Total Cost
RS3400	Engr.	121	5.5	19.03	19.98	39.01
	Engr. Total		5.5	19.03	19.98	39.01
RS3400	Cler	203	.5	.85	.89	1.74
	Cler Total		.5	.85	.89	1.74
RS3400	Srvice	315	.5	1.73	1.81	3.54
	Srvice Total		.5	1.73	1.81	3.54
RS3400	Infsys	403	.25	1.00	1.05	2.05
	Infsys Total		.25	1.00	1.05	2.05
RS3400	Admin.	503	1	3.50		3.50
	Admin. Total		1	3.50		3.50
Job 3400 Total			6.75	26.11	23.73	49.84

The responsibility accounting concept is revealed by the section terms, "Engr, Cler, Srvice, and Infsys" which represent the following cost centers, respectively: (1) Engineering; (2) Clerical; (3) Reproduction; (4) Computer. Also, the first digit of the man number designates the cost center in which the direct labor increments are performed, as is shown in the coding system illustrated in Appendix I. If more than one person in a given responsibility unit work on the same search, the performances are listed separately but included in the total figure reported for the cost center. The term "admin" is utilized for computer programming ease to designate the direct sundry expenses with a cost code beginning with the digit, 5, and the last two numbers representing a specific item. These costs are traceable to various cost centers, according to the coding system which can be extended to coincide with the specific operating conditions of a given NASA Regional Dissemination Center. The sixth column indicates the amount of operations overhead calculated by the machine for the related direct labor cost of the job.

The general RSS labor also is reported on the printout, classified by cost code. Consequently, all information necessary for entries to the job order cost sheets is presented. The accounting function simply transfers the cost data for direct labor, direct sundry expenses, and operations overhead recorded for each retrospective search to the related job order cost sheet which also serves as a subsidiary ledger for the RSS control accounts.[2] The total general RSS labor costs are averaged

---

[2] A control account is a summary record in the cost accounting ledger that is supported by a set of subsidiary ledger accounts. The subsidiary accounts contain a detailed listing of the transactions summarized in the control account.

over the number of searches performed during the period and also are registered on each job order cost sheet. If a job is started and completed during the month, the aggregation of these costs represents the unit search cost. However, when a retrospective search is initiated in one month and finished in a different period, the same procedure must be repeated (each month the job is worked on) to collect the appropriate costs. In this case, the expenses are deferred to the month when the job is completed. The job order cost sheet contains a provision for entries from several periods so it provides a cumulative record of the unit search costs.

Control Ledger Entries

Another section of the monthly cost performance report indicates the total RSS costs, identified by cost classification, registered during the month. Figure 4-4 illustrates this feature. The cost classification

Figure 4-4

RSS Cost Totals By Cost Center

Section (Cost Center)	Base Cost	Operations Overhead	Total Cost
Engr	477.39	501.03	978.42
Cler	98.67	103.51	202.18
Srvice	378.97	397.66	776.63
Infsys	8.74	9.17	17.91
Admin	275.35	-0-	275.35

totals provide essential information for the monthly postings to the cost accounting ledger. The summation of the five figures shown in the Total Cost column represents the amount which must be charged each month to the RSS in Process control account. The latter account signifies the amount of costs recorded for the jobs in process at the beginning of the month or initiated during the period. A total of the unit RSS costs transferred from the monthly computer printout to the individual job order cost sheets is equal to the summation of the five numbers in the Total Cost column of Figure 4-4. After the entry is made to RSS in Process, the cost of the searches completed during the month must be charged to the Finished RSS account. The job order cost sheets of the terminated searches are selected, and the total costs recorded on the forms indicate the amount that must be transferred to Finished RSS.

The job order cost sheets provide an efficient subsidiary ledger for the two RSS control accounts, RSS in Process and Finished RSS. While the searches are being performed, the total costs registered on the related cost sheets furnish an itemized accounting of the balance of the RSS in Process account. A job order cost sheet is reclassified as a record subsidiary to the Finished RSS account when a search is terminated so the cost of the completed retrospective searches is revealed both by a summation of the associated cost sheets and the balance of the control account. The essential cost information necessary for the RSS file updating process is obtained from the monthly cost performance printouts related to the production of the searches. The general-subsidiary ledger relationship is illustrated in Figure 4-5.

Figure 4-5

RSS General-Subsidiary Ledger

General Ledger	RSS in Process	Finished Service →	Finished RSS
Subsidiary Ledger	Job Order Cost Sheets of Work in Process	Transferred When Finished →	Job Order Cost Sheets of Finished Searches

RSS COMPUTER MAINTENANCE

General Nature

One remaining expenditure must be considered for the determination of unit RSS costs. Computer maintenance time is required to update the information file stored on magnetic tape. All computer searches should benefit from the procedure since the primary objective of the maintenance runs is to increase the number of documents available in the NASA file. Therefore, a portion of the updating costs must be charged to individual retrospective searches for realistic unit costs.

The model developed by Marron and Snyderman for the distribution of computer maintenance time to the searches performed at the Science Information Exchange is not feasible for the proposed cost accounting system since the basic premise of their model is the fact that the maintenance runs of a given period are distributed over the searches of the same duration.[3] Since cost information is required in a NASA Regional Dissemination Center on a current basis due to its business firm orientation, the cost system has been designed to collect the service costs continuously and to generate unit cost data as soon as a job is finished. Consequently, an application of Marron and Snyderman's model would distribute the RSS computer maintenance charges incurred during each month over the search activity of the same period. The ratio of the monthly updating costs to the retrospective search volume would determine the average unit maintenance cost, and fluctuations in either the

---

[3] Harvey Marron and Martin Snyderman, Jr., "Cost Distribution and Analysis in Computer Storage and Retrieval," American Documentation, XVII (April, 1966), p. 89.

numerator or denominator from month to month would produce erratic unit search costs.

Proposed Solution

A similar phenomenon exists in the application of operations overhead where volatile unit costs may arise if the actual monthly overhead expenses are distributed over the actual service activity. Typically, overhead costs vary between monthly periods due to such items as maintenance, repairs, heat, and supplies while monthly service volume normally changes as a function of certain seasonal or cyclical factors.[4] The result is an erratic charge to individual production units and an adverse effect on the unit service costs. As is mentioned in Chapter 3, a flexible overhead budget is utilized to overcome the problem as the operations overhead is estimated for varying budget levels, and a predetermined rate is selected from the normal service volume.

It is proposed that the same approach should be taken for the distribution of the RSS computer maintenance time to the individual searches. RSS computer maintenance costs should be estimated for each year and compared with the number of retrospective searches predicted for the normal service activity. A predetermined rate can be calculated from this ratio and used to apply the updating expenses. The procedure will provide an objective basis for the inclusion of a fair share of the maintenance charges and is realistic since the costs are recognized at the time the searches are performed.

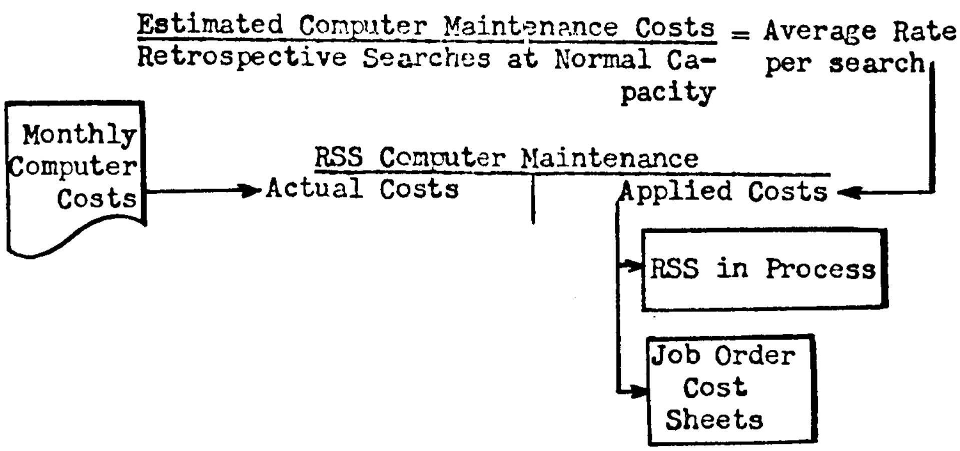
---

[4]Charles T. Horngren, Cost Accounting—A Managerial Emphasis (2nd ed.; Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1967), p. 83.

The ratio shown in Figure 4-6 and the related cost accounting flow illustrates the mechanics of RSS computer maintenance cost distribution.

Figure 4-6

RSS Computer Maintenance Cost Distribution



A monthly computer printout serves as the source document for the RSS computer maintenance charges (See the discussion concerning RSS computer time measurement on page 111). These actual maintenance costs are charged monthly to an account established for the updating function in the chart of accounts. As the searches are performed, the predetermined RSS computer maintenance rate is applied to each search via the job order cost sheet and a credit entry is recorded in the RSS Computer Maintenance account. Consequently, each unit RSS cost contains an appropriate share of updating expenses. At the end of the accounting period, the balance of this account should be reconciled by charging or crediting an underapplication or overabsorption, respectively, of the computer maintenance expenses to the cost of services performed during the year.

REPRESENTATIVE RSS PRICE

Use of the Average Cost

The job order cost sheets provide a record of the costs charged to each retrospective search performed during an accounting period. Unless the service is priced on the basis of actual costs incurred during the work performance, the array of past cost data must be condensed into a representative statistic for pricing purposes. The use of actual costs implies that the clients would not be informed of the cost of an information search at the time a request is initiated. Consequently, the clientele acceptance of such a pricing policy is questionable, and the use of a representative figure which can be quoted prior to the literature search appears to be a more effective procedure.

The arithmetic mean provides a measure of the central tendency of an array of data so it should furnish an objective representation of a set of RSS unit costs. Despite the existence of variances in unit costs, most fluctuations tend to balance out over a lengthy period of time. Since fixed and variable costs are included in the average cost, its utilization is valuable for a NASA Regional Dissemination Center due to the heavy fixed cost committment. Other pricing techniques, such as one based on marginal or incremental costs, disregard the fixed costs and are not feasible for a technical information center.[5] While a particular search may cost more or less than the average figure, the deviations below and above the mean balance out to zero when the total units are

---

[5]Richard H. Leftwich, The Price System and Resource Allocation (Rev. ed.; New York: Holt, Rinehart, and Winston, 1963), p. 147.

considered. Although the use of a historical average cost does not guarantee the accomplishment of the breakeven objective, it should offer a high probability of success.

The purpose of this section is to describe the essential features of a statistical sampling plan which will generate a reliable estimate of the average retrospective search cost related to a population of service cost data. The term, "population," refers to the entire universe of RSS cost data for a given period. For example, if 2000 searches are performed during the year, these elements form the population. A sample is a subset of the universe which is selected for an inference concerning a population parameter. The mean cost could be computed from the entire array of data, but this approach would be unnecessarily laborious and costly. Instead, the utilization of a survey sampling design, based on probability theory, provides an economical and reliable estimate of the population mean (referred to as μ). Since management requires RSS cost and operational data periodically for decisions other than pricing, the sampling process provides an effective tool.

Simple Random Sampling

A random sample of job order cost sheets is selected from those related to the retrospective searches of a given period. Hansen, et. al. define a simple random sampling model as follows:

> By the term "simple random sample of n elements" we shall refer to a sample selected from a population in such a manner that each combination of n elements has the same chance or probability of being selected as every other combination.[6]

[6]Morris H. Hansen, William N. Hurwitz, and William G. Madow, Sample Survey Methods and Theory (New York: John Wiley & Sons, Inc., 1953), p. 12.

We assume, for illustrative purposes, that sampling with replacement is performed. This means that once we have chosen a particular observation and noted its value, we replace it in the population of job order cost sheets. A table of random digits provides an effective device for the selection of a random sample.[7] The job order numbers are used to enumerate the N retrospective searches in the population, and the range of these figures determines the integers selected for the sample from the table. For example, if the searches during an annual period are numbered from 0001 through 2000, any digit found in the random process within the bounds of 1 and 2000 is chosen for the sample. The person selecting a sample merely chooses a random starting point on the table and proceeds downward, choosing all numbers within the desired range and disregarding all other figures. The process is repeated until a sufficient number of sample observations are selected. The decision concerning the selection of a sample size is discussed later.

Sample Mean

The mean of the sample observations and accompanying standard deviation are calculated as follows:

$$\bar{x} = \Sigma \frac{x_i}{n}$$

$$s = \Sigma \frac{(x_i - \bar{x})^2}{n-1}$$

where: $\bar{x}$ = sample mean.

x_i = the ith unit RSS cost selected for the sample.

n = the number of selected sample observations.

s = the sample standard deviation.

---

[7] See Robert Schlaifer, Probability and Statistics for Business Decisions (New York: McGraw-Hill Book Company, Inc., 1959), p. 708 for a table of random numbers.

The sample mean provides a reliable estimate of the population average, μ. For several different kinds of underlying population distributions (including the normal distribution), the sample mean satisfies the following desirable characteristics:

1. Unbiased
   If we enumerate over all possible samples, the expected value of the sample mean is equal to the population average μ.

2. Consistency
   The variance of the sampling distribution of $\bar{x}$ decreases as the sample size n increases.

3. Efficiency
   The sample mean possesses the minimum variance of all unbiased estimators.

4. Sufficiency
   We obtain the same information from $\bar{x}$ as we would from all sample observations.[8]

Sampling Precision

The precision of the sample mean as an estimator is measured by the standard deviation of the sampling distribution which can be shown to be (in the case of an infinite population or sampling with replacement), $\sigma_{\bar{x}} = \sigma/\sqrt{n}$. The smaller the standard deviation, the more precise is the estimator, $\bar{x}$. If we select several different samples, $\bar{x}$ may change each time, but if we repeat the process for all possible samples (in this case there are N^n possible), a sampling distribution emerges with a mean equal to μ and a standard deviation of $\sigma_{\bar{x}}$. Consequently, the more variable the population data, measured by σ, the more dispersed is the sampling distribution for $\bar{x}$. Also, the more information we have (large sample size)

[8] Alexander M. Mood and Franklin A. Graybill, Introduction to the Theory of Statistics (2nd ed.; New York: McGraw-Hill Book Company, Inc., 1963), p. 167.

the more precise is the estimator. Since the standard deviation of the sampling distribution represents a measure of the precision of $\bar{x}$ as an estimation of μ, it provides an effective technique with which to choose the appropriate sample size.

Sample Size Decision

Hansen, et. al. list the following two factors that must be considered in the selection of a sample size:

1. How large an error in the estimate can be tolerated before the inference drawn leads to a wrong decision?

2. What risk can be taken that the results of the sample are in error by more than the amount in 1.[9]

The first condition specifies how accurate the sample estimate must be in a given case. For example, it may be decided that an estimate of the average RSS unit cost must be within a $5.00 range of the true population mean. Any estimate outside this range is not acceptable. The second factor defines the required probability that the sample estimate will be within the desired range. Since the sample mean will be distributed normally for large sample sizes due to the Central Limit Theorem, the probability of $\bar{x}$ being within given areas is known according to the conditions of a normal probability distribution.[10] The information concerning the desired range of the estimator and the acceptable risk of a sample mean being within the limits is all that is necessary to calculate the proper sample size. For example, if we desire the sample

---

[9]Morris H. Hansen, William N. Hurwitz, and William G. Madow, op. cit., p. 32.

[10]See Chapter 6 for a definition of the Central Limit Theorem.

estimate to be within a $5.00 range of the population mean, and we want to be 95 per cent sure this event will occur, we can proceed as follows:

1. $2\sigma\bar{x} = 5$ since $\mu \pm 2\sigma\bar{x} = 95\%$ of a normal curve.

2. $2\sigma/\sqrt{n} = 5$ since $\sigma\bar{x} = \sigma/\sqrt{n}$

   Solving for n:

3. $n = \frac{4\sigma^2}{25}$

Usually, we do not know the population standard deviation, σ, so we must estimate it from sample information. As long as a sample is reasonably large ($n \geq 30$), this approximation is valid. Earlier, the sample standard deviation is defined as $s = \Sigma \frac{(x_i - \bar{x})^2}{n-1}$

For illustrative purposes, we assume that this figure has been computed in the past as $20.

Thus, we have

4. $n = \frac{4(20)^2}{25}$

5. $n = 64$

Therefore, we can obtain the desired precision by selecting a sample of 64 job order cost sheets. The sample mean, $\bar{x}$, should provide a satisfactory estimate of the population mean without the time-consuming procedure of working with the entire universe of data. The sample mean serves as a basis upon which a share of the selling and administrative expenses must be added for a full-cost unit price. The sample also may provide important information for other inferences concerning the Retrospective Search Service. Since it should be an accurate representation of the total searches, decisions concerning the service can be made on the basis of sample information as though all of the data are being analyzed.

For example, in the budgeting cycle, the number of engineer labor hours required for the expected number of retrospective searches may be inferred from the sample information. The average cost figures also represent targeted costs which are essential for planning and controlling an information center's operation.

Full-Cost RSS Price

The average retrospective search cost calculated from the sample includes the three service cost elements—direct labor, direct sundry expenses, and operations overhead. A portion of the selling and administrative expenses must be added for the computation of a price which covers a share of all operating costs, thus contributing toward the breakeven pricing objective. The full-cost pricing model shown in Figure 3-4 requires a distribution of the nonservice expenses on the basis of a unit charge calculated as follows:

$$\frac{\text{Selling and Administrative Costs @ Normal Capacity}}{\text{Direct Labor Costs @ Normal Capacity}} \times \text{Average Direct Labor Cost per RSS}$$

Once again, the sample data are used to estimate the average direct labor cost per search concurrently with the calculation of the sample cost mean. The average direct labor cost is multiplied times the ratio of the selling and administrative expenses to the direct labor costs at normal capacity, and the charge is added to the average retrospective search cost. The result is a mean RSS unit cost which includes an objectively determined share of all operating expenses. The full-cost figure should provide a realistic pricing device for individual retrospective searches.

CHAPTER 5

COSTING A SELECTIVE DISSEMINATION SERVICE

SERVICE DESCRIPTION

General Nature

The objective of the Selective Dissemination Service (SDS) is to assist the clients of a NASA Center in maintaining a current awareness of relevant scientific and technical information as it is published. Specific interest profiles are established, and the current portion of the NASA information file is searched every two weeks for subjects germane to each profile. The customers are informed regularly of documents which appear relevant to their subject. Hiller describes the necessity of such a service as follows:

> The fourth item (a current awareness service) concerns an information service to provide an efficent means for enabling the member of the technical staff to keep current; this is the problem most people are concerned about. What is going on in the field today? What is coming out in the literature? This is one that has always presented a problem.[1]

SDS interest profiles are developed through the joint effort of the ARAC staff and the clientele to accomplish the current awareness objective. An interest profile is described as:

> a list of terms which describe the interest of the requestor. The profile sets the specifications under which a search item will be regarded, and hence retrieved, as an answer to the search request.[2]

---

[1]James Hiller, "Management's Evaluation of Information Services," Information Retrieval Management, ed. Lowell H. Hattery and Edward M. McCormick (Detroit, Michigan: American Data Processing, Inc., 1962), p. 58.

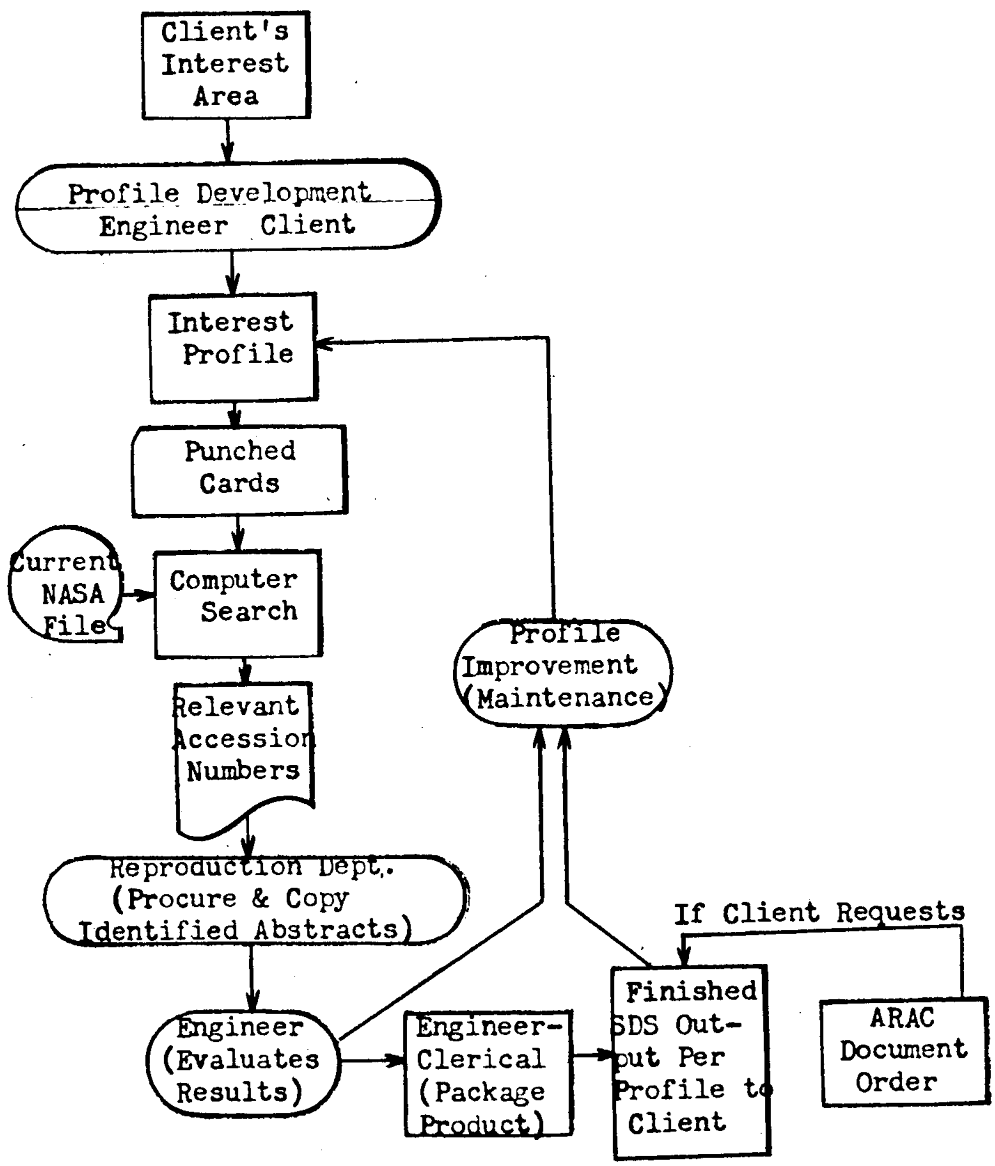
[2]Preparation of Search Profiles (Columbus, Ohio: The American Chemical Society, 1967), p. 4.

SDS Work Increments

The essential operating procedures utilized at ARAC to perform the Selective Dissemination Service are shown in Figure 5-1. A profile is designed through the cooperation of the client and an ARAC engineer

Figure 5-1

ARAC SDS Work Flow



to determine a list of technical terms and their relationship to each other that represent the customer's interest area. A considerable amount of engineer time is necessary for an effective communication of the client's request and the design of an interest profile which contains appropriate terms. The communication process normally is achieved through the engineer's travel to the client's location, telephone conversations, written correspondence, or some combination of the three methods. The customer discloses his interest area in terms of the relevant technology, and the ARAC engineer transcribes the request into a profile coding process suitable for computerized searching.

The terms selected as relevant to the interest area are keypunched onto cards which are matched every two weeks by a computer search against the current segment of the NASA information file. The computer records the accession numbers of documents identified as germane to the interest profile, and the reproduction department uses the printout to procure and copy the abstracts related to the literary work. The ARAC engineer responsible for the profile reviews the abstracts and chooses those most applicable to the client's interest area.

A basic difference prevails between the editing process of the Retrospective Search Service and that of the Selective Dissemination Service. The variation is relevant for cost accounting purposes because it influences the SDS costing technique which is developed later in this chapter. Each ARAC engineer services profiles compatible with his technical training and experience. Consequently, the profiles usually encompass relatively homogeneous subjects, and the same abstracts may be identified for several profiles. Also, the editing process for a given profile may require a diminutive amount of direct labor during an individual SDS performance due to a small computer output. A detailed accounting of the entire universe of profile searches would require excessive reporting procedures by the responsible staff members. As a result, specific jobs cannot be identified as effectively as can be accomplished for the retrospective searches which represent heterogeneous units.

The final abstracts selected by the engineer as being relevant to the client's interests are packaged and mailed to the customer. A document service also is offered, at a client's request, to provide the complete document summarized in each abstract. Nonengineering labor is necessary for these stages as well as for those related to keypunching, correspondence, abstract procurement, reproduction, filing, and the computer operation.

A periodic interaction between the client and the ARAC engineer is required to refine the profile so that the production output remains compatible with the customer's changing interests. The combination of information from the client concerning his opinion of the relevancy of the abstracts and the engineer's evaluation of the output of each SDS performance contributes toward the profile improvement objective. The engineer also utilizes computer maintenance time for a profile analysis that produces information applicable to the refinement process. A list of document numbers is submitted to the computer, and the machine reports a listing of all index terms for the documents as well as the number of documents indexed under each term.

Therefore, the SDS work increments can be divided into three main categories: (1) Development; (2) Operational; (3) Maintenance. The development segment is needed to establish functional interest profiles. Operational work is the recurring production effort utilized to match the relevant terms of each profile against the current portion of the NASA information file by computer and to evaluate the results. SDS maintenance is necessary to refine the interest profiles so they remain compatible with the client's interests. The trichotomy is essential for the design of an objective SDS cost system.

OPERATIONAL COST DETERMINATION

General Concepts

Due to their diverse nature, each SDS work element requires a separate costing technique for the calculation of realistic unit profile costs. A unit profile cost represents an attributable portion of the operational, development, and maintenance expenses for a given interest profile on an individual SDS performance. The purpose of this section is to describe the process costing method used to account for the SDS operational costs consumed in the profile searching function. In a process costing system, all costs of a given period are collected for a specific function but are not related to individual production units. In essence, the total costs accumulated are averaged over the units produced during the period. Gillespie describes the method as follows:

> A process cost system is one in which unit product costs are determined for a period with reference to (a) production costs and (b) units produced for the period.

> The unit cost is accordingly an average cost for a period. The period is often one month, but it may be of any length, for instance, a day or a week. Having a regular cut-off based upon a period of time, it is to be distinguished from job order costing in which a unit product cost is computed for each production order.[3]

The proposed SDS process costing technique differs significantly from the job order method suggested for the Retrospective Search Service since the latter is composed of heterogeneous production units. The searches performed on the interest profiles are not considered separable jobs for costing purposes since minutely detailed reporting would be required by the responsible personnel. Such costs as engineering and nonengineering labor, reproduction charges, telephone calls, supplies, and computer time are consumed in small increments for many individual profiles during each SDS performance. Also, as mentioned earlier, the output for more than one profile may be interrelated during a given profile search. Such itemized accounting procedures as those required in a job order system would require laborious reporting on the source documents to record the numerous cost inputs related to each interest profile. Consequently, it is not feasible to attempt to distinguish between units when accounting for the entire universe of profile searches, and a modified process costing technique is proposed.

Basic Assumption

A weighted-average distribution of the SDS operational costs to the profiles is achieved through a modified process costing method. In a traditional process costing system, the unit costs essentially are determined as follows:

---

[3]Cecil Gillespie, Cost Accounting and Control (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1957), p. 308.

$$\frac{\text{Total cost of material, labor, and manufacturing overhead for each process for the accounting period}}{\text{Total production units for each process for the accounting period}} = \text{average unit cost for each process}$$

Fundamentally the same approach is used in SDS costing except the mean unit cost represents a weighted-average value. A basic assumption is adopted that the operational costs incurred for each profile search depend on the number of abstracts identified in the current segment of the NASA file by the computer. The proposition is stated as follows:

$$\text{Unit profile cost per SDS performance} = f\left(\text{Number of abstracts identified for the profile per SDS performance}\right)$$

This relationship signifies that the dependent variable, unit profile cost, varies as a function of the independent variable, the number of abstracts. The effect of the basic assumption is a weighted-average distribution of the total operational costs recorded through the accounting system for each SDS performance. The ratio of the abstracts identified for a particular profile to the total abstracts revealed by the computer search is multiplied by the total charges accumulated by the process costing mechanism on the related SDS performance. If costs are utilized as a basis for service prices, the weighted-average costing method makes an effective profile development and maintenance essential since the center charges the clients on the basis of the number of abstracts identified by the computer. The customers are required to pay for an ineffective profile if the relevancy ratio (engineer selected abstracts to those identified by the computer) is low with this policy.. Figure 5-2 illustrates the weighted-average technique for five hypothetical profiles as the total SDS costs are distributed at the rate of \$1.20 per abstract $\left(\frac{\$120}{100}\right)$.

Figure 5-2

SDS Weighted-Average Cost Distribution

Profile Number	Abstracts Identified	Total SDS Cost per Run	Weighted Average Ratio	Cost per Profile
50	32		32/100	$ 38.40
51	15		15/100	18.00
52	25		25/100	30.00
53	21		21/100	25.20
54	7		7/100	8.40
Total	100	$120	100/100	$120.00

The same procedure is employed for each SDS performance to calculate the unit profile operational costs. When a large number of interest centers are serviced and the quantity of abstracts identified is voluminous, manual arithmetic calculations may be unwieldy. The computer provides an efficient mechanism through which the weighted-average distribution of the total costs can be achieved. An example of a program, written in FORTRAN, which will furnish a weighted-average breakdown of varying process cost levels is presented in Appendix III. The program can be revised to satisfy specific operating conditions and costs of a given NASA Regional Dissemination Center, but it must be used in conjunction with the regular SDS search program. The computer performs the necessary calculations by multiplying the ratio of the abstracts identified per profile to the total abstracts disclosed in an SDS run times various cost levels established in the program. Once the total operational costs of an SDS performance are known, the related column of the computer printout generated for the run provides a complete weighted-average distribution to the individual profiles.

Justification of the Assumption

An analysis of the SDS work flow shown in Figure 5-1 discloses the fundamental rationale for the assumption that the unit profile operational costs are a function of the number of abstracts identified. The major SDS operational cost elements are:

1. Computer searching time.
2. Computer operation labor.
3. Clerical work to procure the identified abstracts.
4. Reproduction department expenses to copy the abstracts.
5. Engineering labor to edit for relevant abstracts.
6. Clerical work to package and mail the final product.
7. Operations overhead applied to the direct labor costs recorded during the process.

The distribution of the computer searching costs on the basis of the identified abstracts appears logical since the individual interest profiles should receive an approximately commensurate utility from the costs. The magnitude of the other SDS operational expenses may not vary directly as a function of the number of abstracts identified per profile, but the actual behavior should be a close approximation to a linear function within a relevant range of activity.[4] For example, the amount of engineering time necessary to edit the output of a given profile normally will fluctuate in proportion to the number of abstracts which must be evaluated. The more abstracts the engineer has to analyze, the more time the process will require. The nonengineering labor consumed in the SDS process also should vary for individual interest profiles in

---

[4]Charles T. Horngren, Cost Accounting - A Managerial Emphasis (2nd ed.; Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1967), p. 195.

a similar fashion since large work increments are required to service numerous abstracts and the opposite relationship prevails for a diminutive output. Consequently, the assumption that the unit profile operational costs are a linear function of the number of relevant abstracts appears realistic as an approximation for cost distribution purposes.

Operational Cost Accumulation

The source documents discussed in Chapter 3 serve as evidence of the direct labor and direct sundry expenses consumed during each SDS performance. Figure 5-3 illustrates the essential direct cost-source document relationships utilized for SDS operational cost accumulation. The same source documents are employed for the related expenditures consumed in the development and maintenance functions discussed in the next section.

Figure 5-3

SDS Operational Cost Accumulation

Cost Item	Source Document
Labor	Daily Time Ticket
Reproduction Costs	Work Order
Telephone	Telephone Record
Computer Time	Monthly Computer Cost Record
Travel	Travel Voucher

As the individual interest profiles are serviced during the production process, the cost increments are recorded as SDS operational expenses on the proper source document. A share of operations overhead also is charged to the service during the computerized processing in proportion to the total direct labor cost. The source documents are identical to those applicable in the RSS job order technique, and the essential difference between costing the two services is the orientation of the source information. Since the direct cost increments are not readily identifiable with specific profiles when the entire population of profiles is accounted for, they are traced only to each SDS performance. As an operational cost item is incurred, it is recorded by the responsible individual on the appropriate source document as a charge to the related SDS run. A cost code designating the operational nature of each expense is utilized for the source information recording process and is illustrated in Appendix I. For example, the term, SD01, can be used to record all operational expenses incurred on the first SDS performance of the year. The total operational costs are accumulated and reported via the electronic data processing function discussed later in this chapter. When an SDS performance is completed, the total operational costs are distributed to the interest profiles on the weighted-average basis previously discussed, thus designating the portion of the unit profile costs attributable to the search process.

NONOPERATIONAL COST DETERMINATION

Development Costs

SDS development costs are consumed in the establishment of the interest profiles and benefit the profile searching process of subsequent periods. If the expenses are charged to the period in which they are incurred, an unrealistic matching of costs and resulting benefits would occur. Such a practice also would create a fluctuating level of the

SDS process expenses charged to the interest profiles, thus producing volatile unit costs. The direct labor and direct sundry expenses consumed during the development of each interest profile are recorded on the appropriate source document, classified by the profile number and development category. For example, the code SDD50 can be used to designate development expenditures for profile 50. The major development costs are:

1. Engineering labor to communicate with the clients and design a list of appropriate profile terms.
2. Keypunching work to develop the punched cards which are matched against the NASA file.
3. Clerical work for various miscellaneous stages of the development phase.
4. Engineering labor to test the effectiveness of the profile terms.
5. Computer labor to test the effectiveness of the profile terms.
6. Travel
7. Telephone calls
8. Computer time
9. Supplies
10. Operations overhead

Profile development expenses are analogous to those incurred by a business firm in a product research and development project. Consequently, an objective distribution of the development costs to the profiles requires similar considerations as those applicable to the R & D expenditures. The staff of Arthur Andersen & Company, a Certified Public Accounting Firm, discusses the basic objective of accounting procedures for the product R & D costs as follows:

> The desirable objective is clear—that there should be a proper matching of such costs with resulting benefits. Accordingly, where the research and development costs can reasonably be identified with specific projects, or where some other suitable basis can be established, it may be appropriate to defer such costs (1) to be amortized over an appropriate period against the income from the resulting products or product improvements, or (2) to be written off if and when it becomes reasonably foreseeable that such costs will not be recovered from the results of the projects.[5]

The Chief Accountant of the Securities and Exchange Commission expresses the opinion that companies which design new products usually consider the development costs as capital expenditures and amortize them over the estimated life of the products.[6] The profile development costs clearly benefit all SDS searches enacted on the related interest profiles in subsequent periods so a portion of the charges should be distributed to each performance. Otherwise, a misrepresentation of unit profile costs will arise. Since costs are suggested as a basis for service prices, the exclusion of a portion of the development expenses would be detrimental to the financial breakeven objective of a NASA Regional Dissemination Center. The majority of the SDS "start-up" costs would be expensed during the initial stage of a center's operation without any evidence of the investment in the profile development. Consequently, it is hypothesized that the most realistic accounting procedure is to treat the development costs of each profile as an asset since they clearly benefit future accounting periods.

---

[5]Accounting and Reporting Problems of the Accounting Profession (2nd ed.; Chicago, Illinois: Arthur Andersen & Company, 1962), p. 91.

[6]"Memorandum Prepared by the Office of the Chief Accountant, Securities and Exchange Commission," Inventory of Generally Accepted Accounting Principles for Business Enterprises, ed. Paul Grady (New York: American Institute of Certified Public Accountants, Inc., 1965), p. 390.

A client's interests normally change with technological progress so the profiles represent revenue-generating assets for a limited duration. The expiration of the profile development asset should be recognized through periodic amortization charges which are described by the Accounting Principles Board as:

> The cost of a productive facility is one of the costs of the services it renders during its useful economic life. Generally accepted accounting principles require that this cost be spread over the expected useful life of the facility in such a way as to allocate it as equitably as possible to the periods during which services are obtained from the use of the facility.[7]

The average profile life represents the expectation of the existence of the interest profiles so it should provide an objective basis for the amortization charge.[8] The number of SDS performances expected during the average profile life is divided into the development costs of a given profile to determine the appropriate amortization rate. For example, if the life expectancy is five years for a profile serviced bi-monthly and the development expenditures are $900, the amortization rate per SDS performance is calculated as follows:

$$\frac{\text{Total Development Costs}}{\text{Average No. of Profile Searches}} = \frac{\$900}{120} = \$7.50 \text{ per SDS Run}$$

The appropriate rate is charged to the related interest profile for each SDS performance via the data processing function. The procedure provides a systematic distribution of the development expenses, thus

---

[7]Accounting Research and Terminology Bulletins (Final ed.; New York: American Institute of Certified Public Accountants, 1961), p. 76.

[8]The term "expectation" is used here in a statistical sense to refer to the quantity calculated by multiplying each possible value of the random variable, profile life, times the probability of that value occurring and summing the products.

furnishing an objectively determined increment in the unit profile cost. If a client cancels the profile before the development costs have been amortized completely, the remainder should be charged to the income statement as a loss on the design of the interest profile for that client. When more than one profile is developed at the same time, the total development costs should be divided among the related profiles, and each increment should be amortized over the individual lives.

Maintenance Costs

SDS maintenance costs are required for minor improvements to the relevancy of the terms included in the interest profile. Such expenditures as engineering labor, nonengineering labor, telephone calls, and computer time are consumed in the profile refinement function. Changing technology, clientele interests, and descriptors create a need for the periodic maintenance. A share of these charges must be included for the calculation of realistic unit profile costs.

If a major betterment to the interest profile is performed, the necessary expenditures should be considered SDS development costs since generally accepted accounting principles recommend that the cost of a material improvement to an asset should be added to its value.[9] However, the profile refinement process is not a major revision since its purpose is to maintain each profile in an effective operating condition, given the continuing customer interests.

---

[9]Ralph Dale Kennedy and Stewart Yarwood McMullen, Financial Statements - Form, Analysis, and Interpretation (4th ed.; Homewood, Illinois: Richard D. Irwin, Inc., 1962), p. 45.

Two major features of the SDS maintenance expenditures complicate an objective distribution to the individual profiles:

1. Cost increments usually cannot be identified easily with specific interest profiles.

2. The amount of maintenance costs and the number of profile searches normally vary from period to period so estimated costs and SDS service activity must be utilized for distribution to the profiles.

Maintenance costs cannot be identified separately for the individual profiles since several interest profiles of a similar type normally are serviced concurrently during the refinement process and small labor increments often are consumed. A parallel problem is confronted in the SDS operational cost accumulation phase and is the rationale behind the utilization of process costing rather than job order. Therefore, a similar process costing technique is necessary for the maintenance charges to prevent the requirement of minutely-detailed reporting. The costs incurred during the maintenance process are recorded on the appropriate source document, classified by the SDS maintenance code (for example, SDM), to accomplish this objective.

The second complexity is caused by the irregularity of the maintenance expenditures from period to period. These costs are analogous to those incurred in the RSS file updating function and should be charged to the service on the basis of estimated costs and expected search activity. Otherwise, the normally irregular SDS maintenance charges would produce fluctuating unit profile costs, thus hindering the determination of representative figures. The problem parallels the issue discussed in Chapter 3 concerning the distribution of operations overhead to the services. In order to overcome the possibility of volatile unit profile costs, the estimated SDS maintenance charges should be averaged over the searches expected to benefit from the refinement process.

Figure 5-4

SDS Maintenance Cost Distribution

$$\frac{\text{Estimated Annual SDS Maintenance Costs}}{\text{Expected Number of Profile Searches @ Normal Capacity}} = \text{Unit Maintenance Charge Per SDS Run.}$$

The rate calculated in Figure 5-4 provides the mechanism for the application of the SDS maintenance costs to individual profiles on a current basis. The actual expenses consumed during the profile refinement process are recorded on the appropriate source document and reported via the electronic data processing function. At the end of an accounting period (normally a year), any variance between the actual maintenance costs and those applied to the searches must be reconciled. The mechanics underlying the relationship of the actual and applied maintenance charges are discussed in the next section.

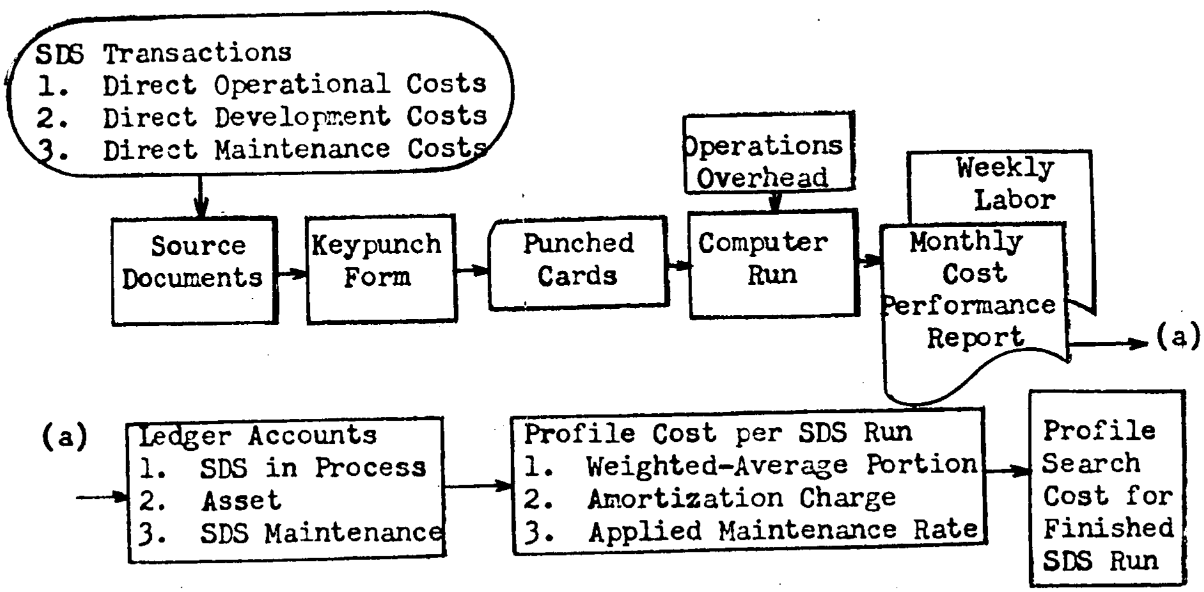
DATA PROCESSING FUNCTION

General Scope

The essential feature of the SDS data processing function is the classification of the total costs on the basis of their purpose—operational, development, and maintenance. The cost items recorded for each of the three elements must be processed and distributed separately to the profiles. Development costs represent the only items identifiable with specific interest profiles so the other two classifications must be averaged over the profile searches. Source information related to the Selective Dissemination Service is recorded and processed by the appropriate classification to accomplish the unit costing objective. The electronic data processing procedures described in Appendix I provide an efficient transition from the source information accumulated during the production operation to the permanent cost records. The essential elements of the SDS costing process are shown schematically in Figure 5-5.

Figure 5-5

SDS Cost Data Processing



Computerized Processing

SDS labor information—categorized as operational, development, or maintenance—is transferred from the daily time tickets to the keypunch form for computerized processing. After the data are keypunched and sorted, a computer run produces the weekly labor performance report which lists the time spent on all three types of SDS work. At the end of each month, the direct sundry expenses are conveyed from the source documents to the keypunch form for processing through the same computerized procedures. The predetermined operations overhead rate, selected from the flexible budget, is inserted into the computer on a punched card so the machine calculates the applied indirect charges concurrently with the direct labor costs. The result is a section of the monthly cost performance printout which itemizes the cost increments consumed during the period for each SDS work element. Abbreviated segments of the cost report are illustrated for the three SDS expense elements in the following sections.

Operational Costs

The cost performance printout contains the information required to record the monthly SDS operational expenses in the cost accounting ledger. In Figure 5-6, the job code, SD10, indicates operational charges for the tenth SDS performance of the year while the man codes signify the cost increments expended by the different responsibility units—engineering, clerical, service, and computer. Since process cost reporting is utilized on the source documents during the SDS performance, several individuals within each cost center may record time for the same job code. The total of these charges is shown for each cost center, thus facilitating the responsibility accounting objective. The responsibility accounting classifications and cost terminology shown in the SDS section of the report are identical to those discussed in Chapter 4 for the RSS segment and are explained in detail in Appendix I. Each cost item recorded as an operational expense is reported for individual SDS runs with an accompanying percentage breakdown of the contribution of every

Figure 5-6

SDS Operational Cost Performance

Job	Section (Cost Center)	Man	Hours (Quantity)	Base Cost	Operations Overhead	Total Cost
SD10	Engr	101	13.25	45.84	48.13	93.97
SD10	Engr	102	8.25	28.54	29.96	58.50
SD10	Engr	105	18.50	64.01	67.21	131.22
	Section Engr Total		40.00	138.39	145.30	283.69
SD10	Cler	201	3.00	6.00	6.30	12.30
	Section Cler Total		3.00	6.00	6.30	12.30
SD10	Srvice	302	26.50	39.75	41.73	81.48
SD10	Srvice	304	14.00	19.60	20.58	40.18
	Section Srvice Total		40.50	59.35	62.31	121.66
SD10	Infsys	401	2.00	6.00	6.30	12.30
	Section Infsys Total		2.00	6.00	6.30	12.30
SD10	Admin	504	10	10.00		10.00
SD10	Admin	507	50	50.00		50.00
	Section Admin Total			60.00		60.00
	Job SD10 Total		85.50	269.74	220.21	489.95

Section Percentage of Job SD10

Engr	58.0
Clerical	2.4
Srvice	24.0
Infsys	2.4
Admin	13.2

cost center. The latter figure should contribute toward efficient planning and controlling of the necessary SDS resources.

If the SDS run is initiated and completed during the month, the row entitled, "Job SD10 Total," represents the total cost of the performance. However, if the work is divided between two monthly periods, both cost performance printouts must be analyzed to calculate the total SDS operational costs for that performance. In either case, the aggregate operational cost figure represents the amount which must be distributed to the individual profile searches through the weighted-average technique discussed earlier.

Development Expenditures

Essentially the same format is used for the section of the cost printout shown in Figure 5-7 which contains the SDS development expenditures incurred during a given month.

The job code, SDD50, reflects development costs consumed on profile 50, and the man code reveals the specific cost items recorded on the source documents as profile development expenditures. If other profiles are designed during the month, similar information is reported for each profile. Assuming the development project for profile 50 was started and finished during the month, the $743.75 figure represents the balance of an asset which should be amortized over the expected life of the interest profile. When the development process extends beyond a one month period, a summation of the expenses recorded on the cost printouts associated with the total duration represents the amount of the asset.

Figure 5-7

SDS Development Cost Performance

Job	Section (Cost Center)	Man	Hours (Quantity)	Base Cost	Operating Overhead	Total Cost
SDD50	Engr	101	50	175.00	183.75	358.75
	Section Engr Total		50	175.00	183.75	358.75
SDD50	Cler	204	5	10.00	10.50	20.50
	Section Cler Total		5	10.00	10.50	20.50
SDD50	Infsys	407	10	30.00	34.50	64.50
	Section Infsys Total		10	30.00	34.50	64.50
SDD50	Admin	507	300	300.00		300.00
	Section Admin Total		300	300.00		300.00
	Job SDD50 Total		65	515.00	228.75	743.75

Section Percentages of Job SDD50

Engr	48.4
Cler	2.7
Infsys	8.7
Admin	40.2

Maintenance Costs

The segment of the cost performance printout shown in Figure 5-8 indicates the actual SDS maintenance costs incurred during the month, classified by individual charges. These expenditures are not distributed to the profiles, however, since a predetermined maintenance rate is charged to each SDS run to minimize the possibility of volatile unit costs. The actual maintenance costs are transferred monthly from the

Figure 5-8

SDS Maintenance Cost Performance

Job	Section (Cost Center)	Man	Hours (Quantity)	Base Cost	Operations Overhead	Total Cost
SD=	Engr	105	6	21.00	22.05	43.05
SD=	Engr	106	8	28.00	29.40	57.40
SD=	Engr	108	10	35.00	36.75	71.75
	Section Engr Total		24	84.00	88.20	172.20
SD=	Cler	202	4	8.00	8.40	16.40
SD=	Cler	204	8	16.00	16.80	32.80
	Section Cler Total		12	24.00	25.20	49.20
SD=	Infsys	401	5	10.00	10.50	20.50
	Section Infsys Total		5	10.00	10.50	20.50
SD=	Admin	507	200	200.00		200.00
	Section Admin Total		200	200.00		200.00
	Job SD= Total		41	318.00	123.90	441.90

Section Percentages of Jobs

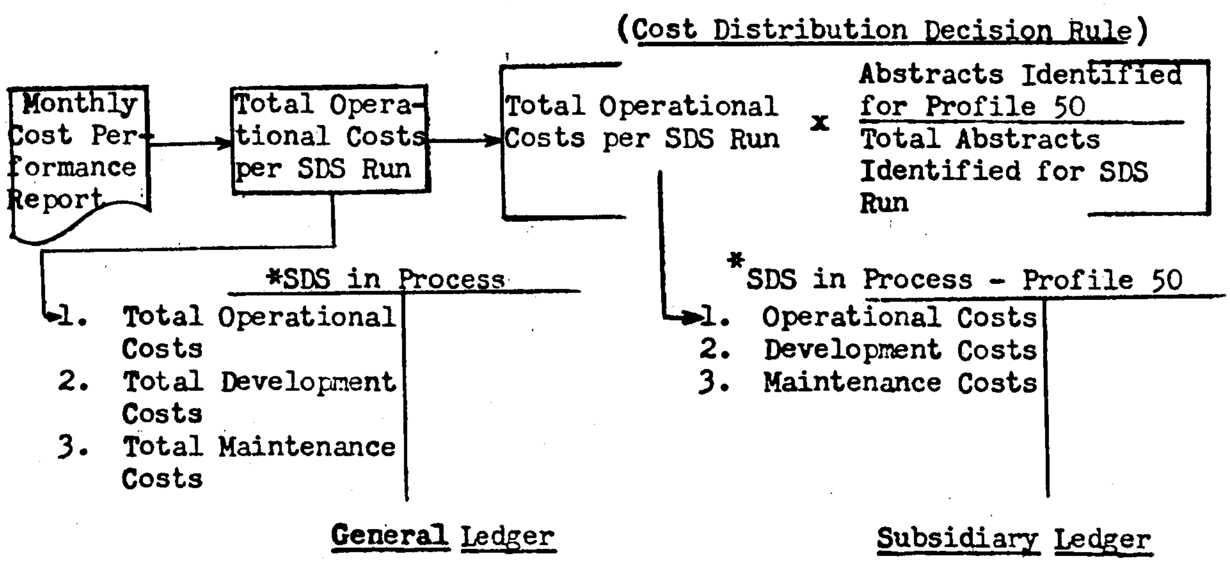
Engr	39.0
Cler	11.2
Infsys	4.8
Admin	45.0

printout to a ledger account for control purposes. A reconciliation between the actual costs reported on the monthly printouts and those applied to the searches must be performed at the end of the year to determine the cause of any variance and to close the difference to the

The total costs are distributed to the individual profile subsidiary accounts by the weighted-average process so a unit operational cost is registered for each SDS profile search. Figure 5-9 reveals the essential features of the cost accounting flow utilized for the operational charges of the hypothetical profile 50.

Figure 5-9

SDS Operational Cost Distribution

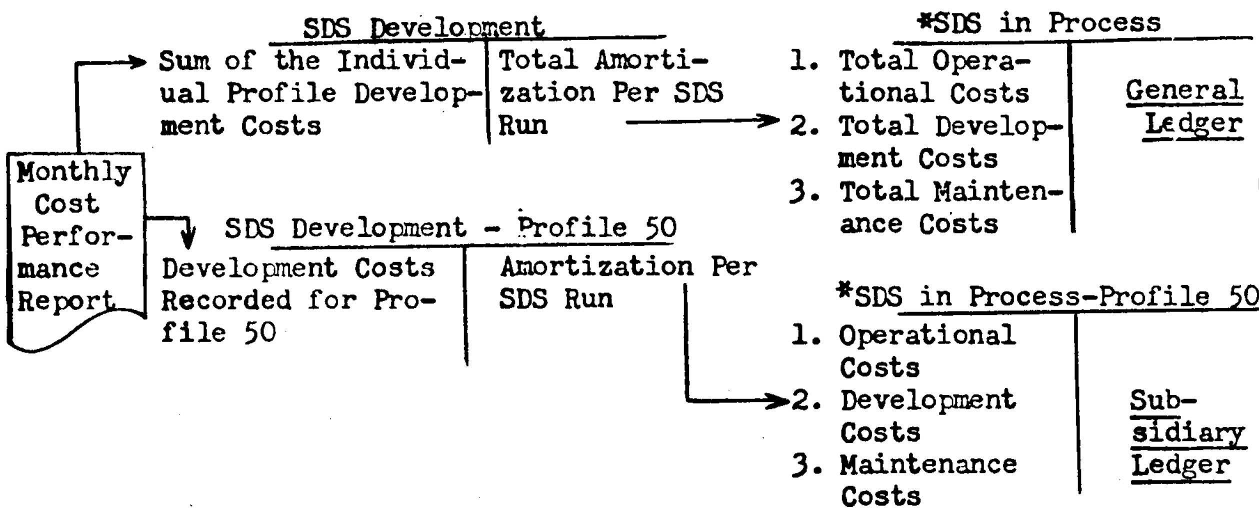


*The three entries are recorded to SDS in Process for each SDS run.

Development expenditures. A subsidiary ledger account is organized for each profile development project, classified by the interest profile numbers. A control account, SDS Development, provides a record of the total profile development charges and represents an asset shown on the balance sheet. The development charges are transferred to the subsidiary accounts from the monthly cost performance printout, and after each design stage is finished for a functional profile, the amortization rate applicable to every SDS performance is charged to the appropriate subsidiary SDS in Process account. An entry reflecting the total period amortization is recorded in the SDS in Process control account. The cost flow of the SDS development process is illustrated for the hypothetical profile 50 in Figure 5-10.

Figure 5-10

SDS Development Cost Distribution

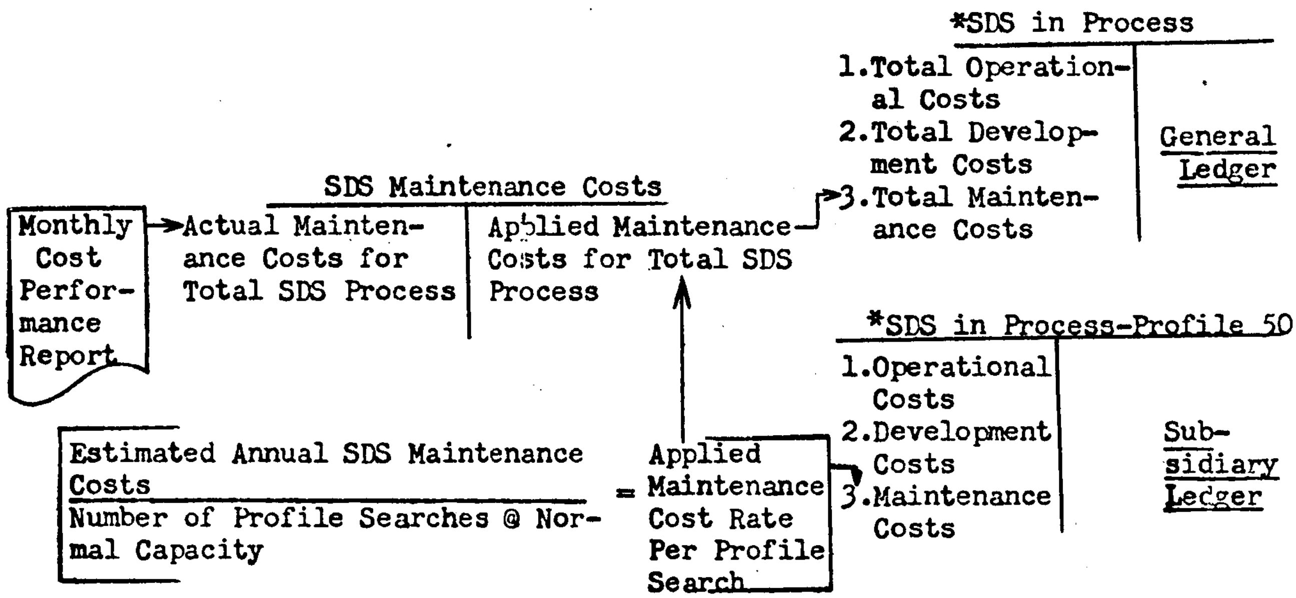


*The three entries are recorded to SDS in Process for each SDS run.

Maintenance costs. A balance of the actual maintenance expenses is sustained by transferring the monthly charges recorded on the cost printouts to a general ledger account, SDS Maintenance. Instead of applying the same figures to the profile searches, the predetermined rate discussed earlier is utilized to minimize the possibility of volatile unit costs. The credit side of the maintenance account indicates the total costs applied, and at the end of an annual period, any difference between the actual and applied figures should be reconciled. If the applied costs exceed those incurred, the variance should be credited to the Cost of Services account. When the opposite relationship prevails, the difference is charged to the same account, thus increasing its balance. The cost accounting flow for the SDS Maintenance costs is illustrated in Figure 5-11.

Figure 5-11

SDS Maintenance Cost Distribution



*The three entries are recorded to SDS in Process for each SDS run.

Finished SDS Performance

After an SDS run is completed, the related costs in process are transferred to a Finished SDS control account. The unit profile costs also are transferred to a group of interest profile subsidiary ledger accounts which support the control account. The result is a complete record of all SDS costs, classified by performance, incurred by the center. The Finished SDS subsidiary ledger accounts represent itemized listings of the unit profile costs related to each search process. Figure 5-12 illustrates the SDS in Process - Finished SDS relationship.

Figure 5-12

Finished SDS Cost Accumulation

SDS in Process		→	Finished SDS		
1. Total Operational Costs 2. Total Development Costs 3. Total Maintenance Costs	Total Unit Profile Costs	→	Total Cost-Individual SDS Run		General Ledger

SDS in Process - Profile 50		→	Finished SDS - Profile 50		
1. Operational Costs 2. Development Costs 3. Maintenance Costs	Unit Profile Cost	→	Profile 50 Cost - Individual SDS Run		Subsidiary Ledger

Unit Profile Cost Summary

The result of the transactions described in the SDS data processing function is a unit profile cost which is based on a portion of the three service cost elements—operational, development, and maintenance. The comparatively homogeneous nature of the production units constrains any objective attempt to trace specific cost items to the related interest profiles during the information searching operation and the profile refinement process. Only the development expenditures are chargeable to individual profiles since the interest profiles are relatively heterogeneous during the development stage. Consequently, the operational and maintenance expenses are costed through a process costing technique, and the development expenditures of each interest profile are amortized over future SDS runs. The result of the SDS cost accounting process is a unit profile cost which consists of the following three cost elements:

1. A weighted-average portion of the operational costs, determined by the relative number of abstracts identified for each interest profile.

2. A share of the profile development costs based on the amortization rate.

3. A portion of the SDS maintenance charges applied on the basis of estimated costs and search activity.[10]

REPRESENTATIVE SDS PRICING

General Nature

The array of unit profile cost data must be condensed into a representative value or set of values for pricing purposes. Since the pattern of abstract identification activity heavily influences the unit profile cost, numerous pricing arrangements are possible. If management prefers to offer more than one profile price, charges based on the average number of abstracts identified by the computer during numerous SDS runs (referred to as the average profile pull) provide objectively determined prices. This procedure recognizes the unit variable operational cost behavior that is dependent on the size of the profile pull. Such a pricing method also should be equitable to the clientele since they should benefit from individual profiles in relative proportion to the computer abstract identification activity. Assuming the profile is developed and maintained effectively, the magnitude of the

---

[10]In reference to footnote 15 in Chapter 3, a user of the cost system may employ a formal cost accounting journal as a record of original entry for the following items not reported on the monthly cost performance printout: (1) Amortization charge per profile search; (2) Applied SDS Maintenance cost per profile search; (3) Transfer of finished profile searches to the Finished SDS control account. The combination of the monthly computer printout and the journal provides a complete record of the source of the entries to the ledger system.

profile pull should be a relative measure of a client's benefit from an interest profile since the objective is to provide a current awareness service. If the profile does not generate a sufficient amount of relevant abstracts in relation to the computer pull, it no doubt will be overpriced and unsatisfactory to the client.

The unit profile searches can be classified in a frequency distribution which is based on the abstract pull per interest profile. The frequency distribution indicates the number of times a particular profile pull occurs for a given range of values. The resulting array can be divided to coincide with any number of price levels selected by management. Or, if a single profile price is desired, the SDS cost data can be transformed into a representative value by the calculation of an estimate of the average unit profile cost which offers the same advantages as those discussed in Chapter 4 for the Retrospective Search Service.

Regardless of whether a single value or several values are calculated, a mark-up must be added to account for the selling and administrative costs. The purpose of this section is to describe two general pricing policies, a single price plan and one based on varying levels. These concepts can be revised and extended to satisfy the specific operating conditions and management requirements of a given NASA Regional Dissemination Center.

<u>Single Profile Price</u>

Essentially the same survey sample design principles discussed in Chapter 4 are applicable for the computation of an average unit profile cost. The universe of unit costs contained in the Finished SDS subsidiary ledger are sampled randomly for the calculation of a reliable estimate of the mean profile search cost. A sample size is selected on the basis of the allowable range of error around the true mean and the desired probability of the estimate being within the interval. Each profile search is numbered, and the data are ordered according to the magnitude of the digits. For example, if 300 profiles are serviced 24 times a year, the schematic diagram shown in Figure 5-13 represents the 7200 observations (individual profile search costs) in the SDS cost population.

Figure 5-13

SDS Unit Profile Cost Universe

Profile Number	1	2	3	4	. . . .	300
SDS Run						
1	1	25	49	73	. . . .	7177
2	2	26	50	74	. . . .	7178
3	3	27	51	75	. . . .	7179
4	4	28	52	76	. . . .	7180
	.	.	.	.		.
	.	.	.	.		.
	.	.	.	.		.
	.	.	.	.		.
24	24	48	72	96		7200

A random sample is selected from a table of random digits, employing the same procedures as those suggested for RSS cost estimation. The sample mean is calculated as:

$\bar{x} = \frac{\Sigma x_i}{n}$ where x_i = a unit profile cost selected for the sample

n = the selected sample size.

$\bar{x}$ = the average unit profile cost of the sampled elements.

A portion of the estimated selling and administrative costs must be added to determine a full-cost basis. The sample information also is utilized to estimate the mean direct labor costs related to the average unit profile cost. Using the full-cost concept developed in Figure 3-4, a selling and administrative cost increment is computed as:

$$\frac{\text{Selling and Administrative Expenses @ Normal Capacity}}{\text{Direct Labor Costs @ Normal Capacity}} \times \text{Average Direct Labor Cost per Profile Search}$$

The calculated rate is added to the average unit profile cost determined from the sample information to complete the full-cost objective. A share of all operating costs—development, operational, maintenance, selling, and administrative are taken into account with this procedure. Therefore, a price based on the full-cost unit profile charge should contribute toward the breakeven pricing objective. The cost information also should be essential for planning, controlling, and general decision making in the operation of a NASA Regional Dissemination Center.

Multi-priced Profiles

If management prefers to offer more than one profile price, the SDS population cost data can be utilized in a stratified sampling plan. Instead of calculating a sample mean to serve as a single representative value, the frequency distribution of the SDS profile pulls can be stratified to coincide with the desired number of prices. Stratification is achieved by dividing the distribution into groups such that the elements within each group are more alike than the observations in the universe as a whole.[11] A stratified sampling model generally is used to obtain a

---

[11] Morris H. Hansen, William N. Hurwitz, and William G. Madow, Sample Survey Methods and Theory (New York: John Wiley and Sons, Inc., 1953), p. 40.

more precise estimate of the overall population mean, but in some cases the individual stratum means are the parameters of interest.[12] If multi-priced profiles are desired, the strata can be established such that their mean costs serve as the SDS pricing bases.

Since the largest single service cost element is operational expenses, the unit profile charges tend to vary in relative proportion to the number of abstracts identified. Also, the client's utility should be correlated positively with the magnitude of the profile pull. Consequently, the number of identified abstracts per interest center on each SDS run offers an effective mechanism for classifying the population of profile searches for costing purposes.

Management must decide how many profile prices to make available. Each profile search is assigned a number which identifies a particular interest profile and a specific SDS performance. The frequency distribution of the profile pulls of a given period is calculated and stratified on the basis of the number of abstracts identified per profile to coincide with the desired number of prices. For example, assume that management has decided to offer four profile prices for the 300 profiles mentioned earlier. The profile pulls related to each search are obtained and accounted for in varying intervals of a frequency distribution shown in Figure 5-14.

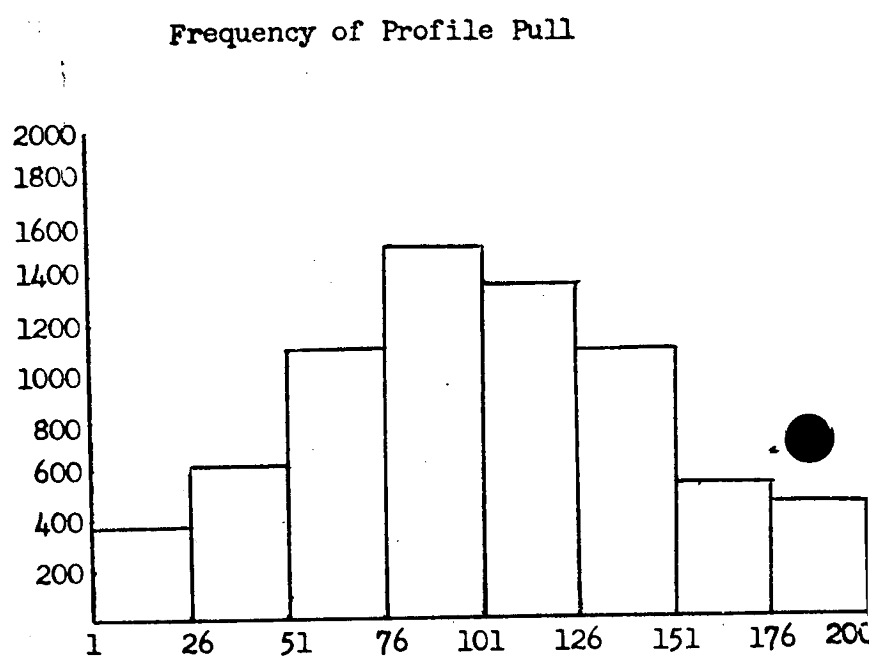
---

[12] Harry V. Roberts, Statistical Inference and Decision (Chicago, Illinois: University of Chicago, 1966), p. 14-26.

Figure 5-14

Profile Pull Frequency Distribution

Profile Pull	Frequency
1-25	360
26-50	612
51-75	1188
76-100	1512
101-125	1368
126-150	1152
151-175	576
176-200	432
TOTAL	7200



Since four profile prices are desired, the frequency distribution is divided into four strata on the basis of the abstracts pulled per profile. The ranges of the subpopulations and the number of elements within each are revealed in Figure 5-15.

Figure 5-15

SDS Stratification Plan

Stratum	Range	Number of Elements	Sample Mean
1	1-50	972	$\bar{x}_1$
2	51-100	2700	$\bar{x}_2$
3	101-150	2520	$\bar{x}_3$
4	151-200	1008	$\bar{x}_4$

Each stratum represents a subpopulation which is of experimental interest since management requires four profile prices. The next step is to identify the costs of each element of the four subpopulations. The predetermined numbers assigned to the individual profile searches permit the matching of stratum elements with unit costs recorded in the subsidiary ledger. A simple random sample, based on the same principles as those employed in the calculation of a single mean, is selected from each stratum to determine estimates of the subpopulation means. Since it appears reasonable to assume that sampling costs per element and the variability within each subpopulation are relatively constant, proportionate stratified sampling is utilized.[13] If these two conditions do not prevail in a given case, optimal (nonproportionate) sampling should be employed. Proportionate sampling means that the sample is allocated to the strata in the same proportion as the total number of observations per stratum which means that:

$$\frac{nh}{n} = \frac{Nh}{N}$$

where: nh = sample for the hth stratum.

Nh = number of elements in the hth stratum. (In this case, h ranges from one to four.)

n = total sample size.

N = total observations in the population (7200).

---

[13]*Ibid.*, p. 14-25.

The sample mean is selected for each stratum as:

$$\bar{x}_h = \frac{\sum x_{hi}}{n_h}$$

where: h = a particular stratum.

i = the ith element chosen from the hth stratum.

n_h = sample size selected from the hth stratum.

$\bar{x}_h$ = sample mean of the hth stratum.

The stratum means provide unbiased estimates of the subpopulation averages which are desired as the bases of different profile price levels. The average direct labor costs per subpopulation also are estimated from the samples selected from the strata and are utilized for the determination of selling and administrative expense mark-ups. The average direct labor costs per subpopulation are multiplied times the selling and administrative factor calculated in Figure 3-4. The result is four profile prices, based on full costs, which differ according to the number of abstracts identified for a given profile. Management can price a particular profile by computing its average abstract pull during a given period and categorizing it in the corresponding stratum. When a new profile is being priced, historical information regarding its abstract pulling activity will not be available. In such cases, the best estimate of its future output should be determined by management and the responsible engineer, using all known relevant information. The engineer may have serviced a similar interest profile and can use its average abstract pull as a prediction of the new profile's activity. If a valid estimate cannot be forecast, an objective solution would be to price all new profiles at the overall average abstract pull and then adjust to the appropriate stratum when actual activity data are available.

CHAPTER 6

STATISTICAL COST CONTROL

INTRODUCTION

General Objective

The purpose of this chapter is to describe a statistical cost control system that will verify the relative performance of the direct costs consumed during the information searches. A statistical approach requires substantially less human effort than is necessary for a formal cost accounting system. For example, since every cost increment is recorded and processed when the proposed cost accounting system is applied in a NASA Regional Dissemination Center, a substantive contribution is demanded of each staff member responsible for a segment of the work activity. Clerical work and managerial analysis time also are required to supplement the electronic data processing function.

Vance summarizes the potential advantages of statistical cost control as follows:

> Where a substantial volume of product is made or some process or operation is done frequently and no continuous, formal cost accounting is done, we can gather cost information and, therefore, exercise cost control by estimating the unit cost from a sample. For example, we may take a sample of time cards for a certain operation and estimate the unit labor cost from them for the period in question. Note that this invokes all the advantages of other applications of sampling theory. We can determine how large a sample to take to give the degree of precision we want in the estimate. We can balance the cost of the sampling against the quality of the result we want. We can use the devices of scientific sampling to determine what items to include in the sample. We can eliminate, if we are careful, the biases that result from use of personal judgement alone in selecting and evaluating samples. In view

> of the fact that complete, formal cost accounting is often considered much too expensive to justify its use in small industrial operations, this should appeal to many cost accountants and to many managements as a means of obtaining cost data scientifically at a reasonable cost.[1]

The statistical cost control model represents a probabilistic technique that will confirm whether or not the direct costs incurred during a retrospective or profile searching process remain "in control" when compared with a predetermined target. If the proposed cost accounting system is utilized for a duration which is long enough that reliable cost data are obtained, these values can serve as the targets of the cost control model. Retrospective and profile search costs are sampled monthly and compared statistically with the predetermined representative values to verify the control status of the search cost processes.

Statistical Cost Control

The statistical cost system is based on the theory of statistical quality control, the objective of which is to ascertain whether or not a given process performs within certain desired control limits. Sample information is obtained regularly from the process and recorded on control charts to isolate operating procedures which require management investigation. Grant describes a state of statisitcal control in the following way:

> Measured quality of manufactured product is always subject to a certain amount of variation as a result of chance. Some stable "system of chance causes" is

---

[1]Lawrence L. Vance, "Capsule Cases in Statistical Cost Control," N.A.C.A. Bulletin, XXXVI (January, 1955), p. 688.

> inherent in any particular scheme of production and inspection. Variation within this stable pattern is inevitable. The reasons for variation outside this stable pattern may be discovered and corrected.[2]

Bowman and Fetter discuss cost control as a possible application of a statistical quality control model as follows:

> The variation in the cost of producing some item may be discovered by an analysis of past performance. Through application of the technique of statistical control, the expected value and limits of variation of this cost with a stable chance cost system may be discovered and thus a mechanism established for identifying assignable causes for variation in cost. Furthermore, the technique aims at improving the cost performance by the following:
>
> 1. Directing attention at both mean costs and variation in cost.
>
> 2. Discovering causes for good, as well as poor, cost performance.[3]

The conventional use of a statistical control chart in the cost accounting area is for the disclosure of materially unfavorable variances from predetermined standard costs.[4] However, in such cases, the statistical device merely supplements a cost accounting system. The objective of the model developed in this chapter is cost control without a formal cost accounting system. Instead of accounting for every production unit, a random sample of information searches is selected, and the direct costs consumed for the sample are recorded and

---

[2]Eugene Grant, Statistical Quality Control (3rd ed.; New York: McGraw-Hill Book Company, Inc., 1964), p. 3.

[3]Edward H. Bowman and Robert B. Fetter, Analysis for Production Management (Rev. ed.; Homewood, Illinois: Richard D. Irwin, Inc., 1961), p. 158.

[4]Howard L. Timms, The Production Function in Business (Rev. ed.; Homewood, Illinois: Richard D. Irwin, Inc., 1966), p. 645.

processed. An inference is drawn from the sample information concerning the entire universe of search costs without a detailed set of accounting records. Parameters of interest are calculated for each sample and recorded on statistical control charts to measure their performance. Since the sampling technique is based on probability theory, the data should be representative of the entire collection of searches. Consequently, cost control of the direct search costs, in relation to those included in a NASA Regional Dissemination Center's price schedule, is achieved in an efficient and economical procedure.

MODEL DEVELOPMENT

General Theory

Fabrycky and Torgersen describe a statistical quality control chart as, "a graphical representation of a mathematical model used to monitor a random variable process in order to detect changes in a parameter of that process."[5] The technique is utilized to verify the output of a particular process which is hypothesized to be "in control" as long as the only variation occurs from random sources. In a NASA Regional Dissemination Center, the direct search costs represent the process that must be controlled to insure that current costs compare favorably with representative values. Statistical cost control limits are established on two charts, and probability theory is employed to predict the deviation in cost performance that is attributable to chance.

---

[5]W. J. Fabrycky and Paul E. Torgersen, Operations Economy: Industrial Applications of Operations Research (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1966), p. 197.

Random samples of information searches are selected monthly, and the relevant statistical parameters are recorded on the related control charts. If a sample value is registered outside the predetermined control limits more frequently than expected from random error, the cost process is defined as "out of control," and managerial investigation is warranted. When the process is "in control," the sample values fall within the acceptable range, and future cost performance can be predicted on the basis of past cost behavior.

Therefore, a statistical inference is performed from the random samples that are selected periodically. A null hypothesis is proposed that the search cost process from which each sample is obtained remains relatively unchanged when related to predetermined cost targets. The sample values are plotted on the statistical control charts to test the null hypothesis. If the cost parameters are within the desired control limits, we conclude that no assignable causes of variation are present since the deviation conforms to a predictable statistical pattern. Duncan lists the following advantages of such a statistical control chart:

> 1. A control chart is a device for describing in concrete terms what a state of statistical control is.
>
> 2. It is a device for attaining control.
>
> 3. It is a device for judging whether control has been attained.[6]

The essential components of the statistical cost control model are an $\overline{X}$ chart (mean chart) and an R chart (range chart). The former is

---

[6]Acheson J. Duncan, Quality Control and Industrial Statistics (3rd ed.; Homewood, Illinois: Richard D. Irwin, Inc., 1965), p. 338.

employed to discover changes in the mean of the cost process while the latter is utilized to measure the performance of the dispersion, as measured by the range of the sample cost data. Both parameters are calculated for each sample and recorded on the related chart to determine the control status of the search cost process.

The $\bar{X}$ Chart

The $\bar{X}$ chart measures variations in sample cost means. A central line is established to coincide with the null hypothesis concerning a representative average direct search cost, and the control limits are based on the characteristics of a normal probability distribution. The Central Limit Theorem states that an approximately normal distribution exists for the sample means. Hoel explains this concept as follows:

> If x has a distribution with mean μ and standard deviation σ for which the moment generating function exists, then the variable $t = (\bar{x} - \mu)\ \sqrt{n}/\sigma$ has a distribution that approaches the standard normal as n becomes infinite.[7]

Even when small samples of size four or five are selected, the Central Limit Theorem insures approximately normal behavior for the sampling distribution.[8] Duncan suggests that samples of size four or five offer the advantages of lower costs and less chance of a change occurring during the sampling stage than larger samples.[9]

---

[7]Paul J. Hoel, Introduction to Mathematical Statistics (3rd ed.; New York: John Wiley and Sons, Inc., 1962), p. 145.

[8]*Ibid.*, p. 146.

[9]Acheson J. Duncan, *op. cit.*, p. 396.

The average direct search cost is calculated for each sample and registered on the control chart to verify whether or not it is within the range of a predetermined target cost plus and minus the desired control limits that are represented by $k\,\sigma_{\bar{x}}$. The standard deviation of the sampling distribution (defined as $\sigma_{\bar{x}}$) represents the variation of the distribution underlying the null hypothesis and k indicates the required precision of the control device. It can be shown that the following values for k determine the corresponding areas of a normal distribution:

If $k = 1$, $\bar{\bar{X}} \pm 1\,\sigma_{\bar{x}} = 68\%$
If $k = 2$, $\bar{\bar{X}} \pm 2\,\sigma_{\bar{x}} = 95\%$
If $k = 3$, $\bar{\bar{X}} \pm 3\,\sigma_{\bar{x}} = 99.7\%$[10]

Thus, if $\pm 2\,\sigma_{\bar{x}}$ are selected for the control limits, only 5 out of 100 sample means would be expected to fall outside the acceptable range due to random behavior. The choice of k should depend on an economic trade-off between the costs of a sample mean falling outside the control limits when the process actually is "in control" and those incurred when the parameter is inside the required range, but the process is "out of control." A decision rule is developed in a later section for the accomplishment of this objective. Once an appropriate value for k is defined, the control limits of the $\bar{X}$ chart are established, and the probability of chance variation outside the limits is known in accordance with the corresponding area of a normal distribution.

The standard deviation of the sampling distribution is computed as:

$$\sigma_{\bar{x}} = \sigma/\sqrt{n} \quad \text{where } \sigma = \Sigma \frac{(X_i - \bar{\bar{X}})^2}{N}$$

---

[10]The parameter $\bar{\bar{X}}$ is the same as μ and both refer to the population mean.

However, the laborious calculations required for this statistic can be avoided by utilizing the range, R, which provides a sufficiently stable estimate of the variation when small samples are selected.[11] The range is defined as the difference between the lowest and highest value in each sample, and it is related to the standard deviation for the determination of the control chart limits as follows:

$d_2 = \bar{R}/\sigma$ where $\bar{R}$ = the mean of the sample ranges.

σ = process standard deviation.

The term d_2, which represents the expected ratio between the average range ($\bar{R}$) and the standard deviation (σ), has been computed for various sample sizes and can be found in published tables.[12] Therefore, the standard deviation of the sampling distribution can be estimated in the following way:

$$\sigma_{\bar{x}} = \sigma/\sqrt{n} = \bar{R}/d_2\sqrt{n}$$

The result is a pair of control limits for the $\bar{X}$ chart that are defined as:

$$\bar{\bar{X}} + \frac{k\bar{R}}{d_2\sqrt{n}} = \text{Upper Control Limit}$$

$$\bar{\bar{X}} - \frac{k\bar{R}}{d_2\sqrt{n}} = \text{Lower Control Limit}$$

Where $\bar{\bar{X}}$ = the average direct search cost established as a target

k = the balance between the costs of a needless investigation and those of an undetected process that is "out of control."

---

[11]Robert B. Fetter, The Quality Control System (Homewood, Illinois: Richard D. Irwin, Inc., 1967), p. 52.

[12]Eugene Grant, op. cit., p. 561.

$\bar{R}$ = average sample direct cost range

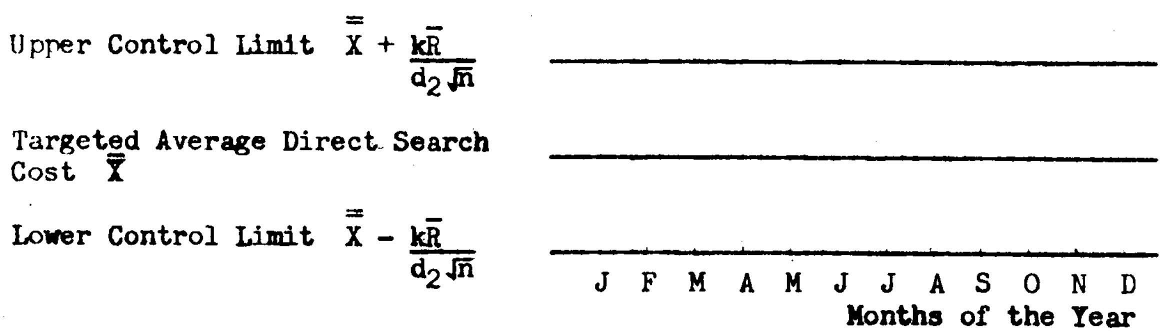
d_2 = expected ratio between the average range and standard deviation

n = sample size

Figure 6-1 illustrates an $\bar{X}$ chart that can be utilized for statistical cost control with the predetermined limits. Unit search costs are sampled monthly, and the average of each sample is recorded on the chart to verify its relationship with the predetermined standard.

Figure 6-1

$\bar{X}$ Cost Control Chart



The R Chart

Essentially the same procedure is followed in the construction of the R chart except the parameter of interest is the range which represents a measure of the direct search cost dispersion. The range is calculated for each sample and compared with $\bar{R}$ which is hypothesized to be the mean range of the cost process. If the null hypothesis is true, the R values should behave within predetermined control limits according to the prescribed conditions of the normal distribution. The control limits are established at $\mp k\,\sigma_R$ with σ_R representing the standard deviation of the distribution of sample ranges. This statistic is computed from a standard value for the process standard deviation, σ. If a sample range is recorded outside the prescribed control limits, evidence of nonrandom variation exists, or in other words there is a strong inference that the search process is "out of control" cost-wise.

The control limits of the R chart are established by estimating σ_R. Bowman and Fetter suggest that a reliable estimate can be calculated as follows:

$$\sigma_R = \sigma_W \frac{\bar{R}}{d_2}$$

where: σ_W is the standard deviation of the sample values of R/σ.

d_2 is the expected ratio between the average range and the process standard deviation.

$\bar{R}$ is the average range of the process.[13]

σ_W has been calculated for various sample sizes and is tabulated in published tables, commonly defined as d_3.[14] Therefore, the control limits of the R chart are computed as:

$$\bar{R} + kd_3 \frac{\bar{R}}{d_2} = \text{Upper Control Limit}$$

$$\bar{R} - kd3 \frac{\bar{R}}{d_2} = \text{Lower Control Limit}$$

Once again, the determination of k defines the desired control limits and requires the same economic considerations as those relevant for $\bar{X}$. These are discussed in the next section. Figure 6-2 illustrates the basic features of an R chart applicable to the cost control function.

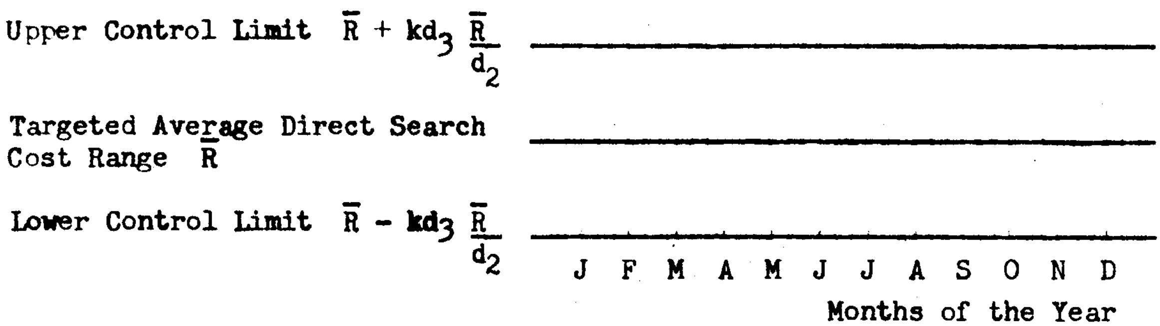
---

[13]Edward H. Bowman and Robert B. Fetter, op. cit., p. 173.

[14]Acheson J. Duncan, op. cit., p. 908.

Figure 6-2

R Cost Control Chart



Control Limits

The customary procedure in statistical quality control is to choose the control limits with the objective of minimizing the chance of investigating sample values recorded outside the acceptable area when the process actually remains "in control."[15] However, adopting a Bayesian decision theory approach, the selection of a significance level in a test of hypothesis should be based on the seriousness of α (probability of a Type I error) and β (probability of a Type II error) rather than the former alone.[16] The number of standard deviations, k, for $\sigma_{\bar{X}}$ and σ_R, should be established for the cost control charts on the basis of an economical consideration of the two types of error. The null hypothesis is specified that the search cost process is "in control" when compared with the central values of the charts. If a sample value for either $\bar{X}$ or R falls outside the control limits without a significant change in the unit direct search costs, an unnecessary investigation

---

[15] Ibid., p. 342.

[16] Harry V. Roberts, Statistical Inference and Decision (Chicago, Illinois: University of Chicago, 1966), p. 11A-6.

might be performed to determine the cause. Consequently, a Type I error occurs since a true hypothesis is rejected. The probability of such an event happening is defined as α, which determines the significance level of the test and is a function of the chosen control limits.

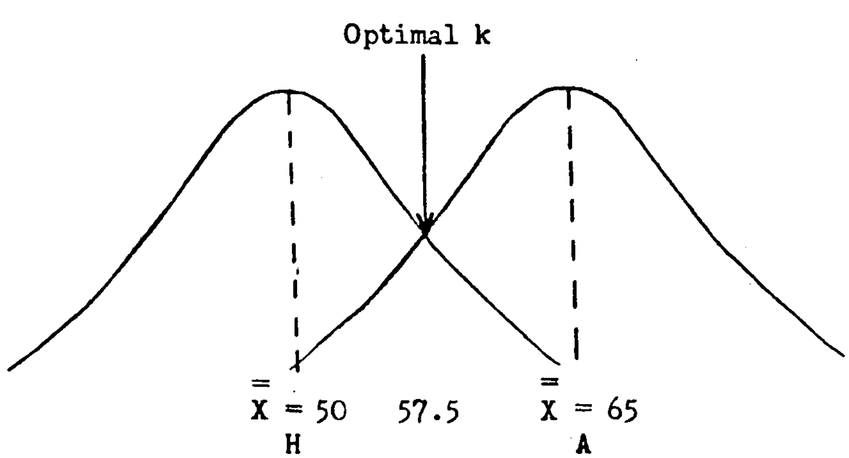
A Type II error arises when a sample value is recorded within the specified control limits, but the process is actually "out of control," causing an acceptance of a false hypothesis. The probability of this error is referred to as β and is dependent upon the frequency distribution of the shift of the process to an "out-of-control" state. If the control limits are established wide apart (k is large), α will be extremely small. For example, if $\bar{\bar{X}} \pm 3\ \sigma\bar{X}$ is used for the $\bar{X}$ chart, the probability of a Type I error occurring is only .003. However, with wide control limits, the chart is not likely to detect small shifts in the average unit search costs so the probability of making a Type II error may be significant when the distribution of the changes is considered. Cost performance data should be recorded and studied so that a frequency distribution can be derived for the previous deviations from the targeted cost parameters.

Both types of error will be expensive for a NASA Regional Dissemination Center if statistical cost control is employed so their consequences must be evaluated carefully for the calculation of appropriate control limits. A Type I error results in needless costs for the investigation of sample values outside the control limits when the direct search costs are actually "in control." Lost revenue arises from a Type II error since the actual direct search costs are actually "out of control," but undetected, when compared with the standard figures utilized for pricing purposes. The latter condition is detrimental to the breakeven objective of a NASA Regional Dissemination Center.

Management must evaluate the seriousness of the two types of error in a given case and select k, the number of standard deviations, accordingly. In order to illustrate the determination of an appropriate k, we assume that management has determined that the two errors are equally serious since the cost of a Type I error is equal to the cost of a Type II error. Also, the null hypothesis is proposed that the representative average direct search cost should be \$50 with $\sigma_{\bar{x}}$ estimated as \$5. Past records indicate that the average upward shift of the cost process to an "out-of-control" state has been \$15, distributed with the same shape and dispersion as that underlying the null hypothesis. Since the two kinds of error are considered equally serious with the same frequency distribution dispersion, the intersection of the normal curve underlying the null hypothesis and that of the alternative hypothesis defines the optimal value for k. The appropriate relationship is shown in Figure 6-3 for the upper control limit.

Figure 6-3

Optimal k-value for Upper Control Limit



Using the standardized normal formula, the distance from the mean to a given value on the distribution is expressed in units of the standard deviation as follows:

$$k = \frac{\bar{X} - \bar{\bar{X}}}{\sigma_{\bar{X}}}$$

Applying this formula to the distributions underlying the null and alternative hypotheses, H and A respectively, two equations are obtained that can be solved simultaneously for the optimal value of k.

$$k = \frac{\bar{x} - 50}{5} = 5k = \bar{x} - 50$$

$$k = \frac{65 - \bar{x}}{5} = \underline{5k = -\bar{x} + 65}$$

$$10k = 15$$

$$k = 1.5$$

Therefore, the optimal value of k sets the upper control limit at:

$$\bar{\bar{X}} + 1.5\,\sigma_{\bar{X}} = 50 + 1.5\,(5) = 57.5$$

The same philosophy can be utilized for the determination of the lower control limit. Consequently, both values of k are derived as a function of an economic trade-off between the seriousness of the two types of error. The exact relationship between the Type I and Type II errors can be calculated to coincide with the operating conditions of a given NASA Regional Dissemination Center.

Arbitrary control limits may be necessary in the initial stages of statistical cost control before a sufficient amount of information concerning the frequency distribution of a shift to an out-of-control state and the relevant costs is available. In such cases, $\pm 3\,\sigma_{\bar{X}}$ and $\pm 3\,\sigma_R$ provide reasonably good approximations to the optimal limits.[17]

---

[17]Acheson J. Duncan, *op. cit.*, p. 343.

MODEL APPLICATION

Representative Search Costs

The null hypothesis of the proposed statistical cost control model is based on the assumption that representative values of $\bar{\bar{X}}$ and R are available. These parameters are employed as measurements of the cost control status of the information searching process. An extensive application of the cost accounting system that was presented earlier should generate a reliable set of cost targets. The same sample information that is used for the determination of service prices (See Chapters 4 and 5) also can serve as the source of the representative direct search costs. The sample data can be tested for consistency between months with the analysis of variance model described in Chapter 3.[18] Once dependable values are designated, the costs of the search processes are hypothesized to be in a state of stable control as measured by $\bar{\bar{X}}$ and $\bar{R}$. As long as the production costs remain "in control," the sample values of each parameter should be recorded within the desired control limits of the appropriate chart. If a value falls outside the acceptable range, managerial action is necessary to determine the cause of the variation.

Direct labor and direct sundry expenses represent the only costs which can be related to specific searches during the production process. Such items as operations overhead, maintenance expenses, and profile development expenditures are charged to the individual searches on the basis of an estimation method when a formal cost accounting system is

[18]The use of the analysis of variance model to test the assumption that monthly average search costs are equal is illustrated with the test period data from ARAC in Exhibit III.

employed, as is explained in Chapter 5. Consequently, the direct charges represent the only portion of the total unit search cost that is controllable by the responsible employees during the production process. Since the indirect costs are not measurable during the search operation, they are not suitable for statistical cost control.

Any deviation in the behavior of the applied indirect charges per search is caused by a fluctuation in the amount of recorded direct labor costs. Operations overhead, profile maintenance, and RSS file updating expenses are a linear function of the direct labor costs recorded for each search since they are absorbed on that basis. Also, the development costs incurred for a profile are amortized over the expected life of the profile so the unit rate charged to each profile search is a constant. Therefore, the total unit search cost can be considered as a linear combination which is dependent only upon the random variable, direct search cost. As a result, the total unit cost should vary proportionately with the direct expenses, and the cost process can be controlled statistically by accounting for the direct costs of sampled searches from each service category.

If management requires a unit search charge that includes a portion of all operating costs, the estimation procedures used for the applica- tion rates in the formal cost accounting system can be employed to distribute a share of the indirect charges. The primary limitation which results from the consideration of the applied indirect costs exclusively is the fact that they must be assumed equal to the actual indirect charges since complete cost accounting records are not maintained in the statistical cost control system.

Although a center will not possess a complete record of each indirect cost item incurred during an annual operation, an inference concerning the control status of the indirect expenses can be performed on the basis of deductive reasoning. By definition, the direct service costs plus all indirect expenses (maintenance, development, operations overhead, selling, and administrative) must equal the total operating expenses. Management should perform an end-of-the-year audit to insure that the total operating expenses relate favorably with those forecast for the cost basis of the pricing schedule. Even though the cost accounting records no longer are maintained with the statistical model, the financial accounting system must be operated to process and disburse the center's expenditures.

Management can use the financial accounting information for an analysis of the magnitude of the operating costs despite the fact that the expenses cannot be related to the services. Since the objective of a NASA Regional Dissemination Center is to operate at a breakeven revenue level, management must be certain that the total costs are not greater than those included in the full-cost pricing basis. The use of statistical cost control for a continuous and economical verification of the production costs and the supplementary annual analysis of the total operating expenses should facilitate the objective of a center.

Sampled Service Costs

A random sample of five searches from each service category, retrospective search and selective dissemination, is chosen every month for statistical cost control purposes. The same randomization procedures discussed in Chapter 4 also are applicable in this section. The random choice assures a high probability that each sample will be representative of all searches performed for the respective service during the period. A sample cost sheet, illustrated in Exhibit XVI, accompanies each search as it progresses through the production process so all unit direct charges are recorded on the same source document. Therefore, instead of the numerous forms and records required for a formal cost accounting system, this single sheet satisfies the cost collection objective. Essentially the same principles as those presented for the proposed cost accounting system are employed during the recording process. All engineering and nonengineering labor, telephone calls, computer time, reproduction charges, and miscellaneous direct expenditures are registered in the physical quantities consumed on the sample cost sheet. When a sampled search is completed, the quantity of each input is converted to the proper cost increment, and an aggregation of the individual entries represents the direct search cost for that unit.

Consequently, each search which is sampled from both the Retrospective Search Service and the Selective Dissemination Service is treated as a unique unit for costing purposes. The procedure is similar to the job order costing technique employed for the Retrospective Search Service in the formal cost accounting system discussed in Chapter 4. This approach is not feasible for the Selective Dissemination Service when every interest profile is accounted for since the relatively minute cost inputs and interrelated service activity would demand prohibitively detailed reporting by the responsible personnel. However, it is hypothesized that each profile search can be considered a separate job in the statistical cost system since a comparatively small number of units must be accounted for each month. The sampled searches should require a minimum amount of work by the responsible employees as they record the related direct costs consumed during the production process. Detailed performance records are not necessary since the employees only register their contribution to the five searches of each service category which are included in the samples.

Illustration of the Model

The objective of this section is to illustrate the utilization of the statistical cost model to control RSS costs for a twelve month period in a hypothetical NASA Regional Dissemination Center. We assume that the unit cost data for 980 retrospective searches performed during the previous year are available in the records of a formal cost accounting system. The samples shown in Figure 6-4 have been selected randomly for the derivation of representative targets for the mean and range of the RSS cost performance. On the basis of the sample data,

Figure 6-4

Sampling for Representative Cost Targets

Sample Number	RSS Unit Direct Costs					Mean $\bar{X}$	Range R
1	$52.60	51.80	51.40	46.40	50.80	50.60	6.20
2	55.40	46.80	52.10	47.10	50.60	50.40	8.60
3	52.40	45.60	55.20	48.40	50.40	50.40	9.60
4	55.70	46.20	48.10	51.80	49.20	50.20	9.50
5	46.60	49.50	53.70	49.40	48.80	49.60	7.10
6	51.80	45.40	46.30	48.10	52.40	48.80	7.00
			Grand Mean			$50.00	
			Grand Range				$8.00

an average direct search cost of $50.00 is chosen for the $\bar{X}$ chart, and a range of $8.00 is obtained for the R chart.

The seriousness of the two types of error possible in the test of the null hypothesis has been evaluated with similar facts as those discussed on page 177, and k = 1.5 has been selected for the upper and lower control limits. Using the mathematical notation developed earlier, we can establish the desired control limits for the two components of the model, the $\bar{X}$ chart and the R chart, respectively.

1. $$\bar{\bar{X}} \pm 1.5\,\sigma_{\bar{x}} = \bar{\bar{X}} \pm 1.5\,\frac{\bar{R}}{d_2\sqrt{n}} =$$

   $$50 \pm 1.5\,\frac{8}{2.326\sqrt{5}} = 50 \pm 2.31 =$$

   52.31 for the Upper Control Limit

   47.69 for the Lower Control Limit

2. $$\bar{R} \pm 1.5\,\sigma_R = \bar{R} \pm 1.5 d_3\,\frac{\bar{R}}{d_2} =$$

   $$8 \pm 1.5\,(.864)\,\frac{8}{2.326} = 8 \pm 4.46 =$$

   12.46 for the Upper Control Limit

   3.54 for the Lower Control Limit

These limits are utilized to verify whether or not the RSS unit direct costs are "in control" when compared with the predetermined targets. The two cost control charts are illustrated in Figure 6-5.

Figure 6-5

Illustration of Statistical Cost Control

$\bar{X}$ Chart

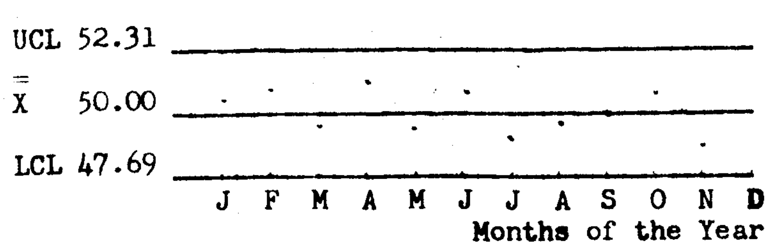
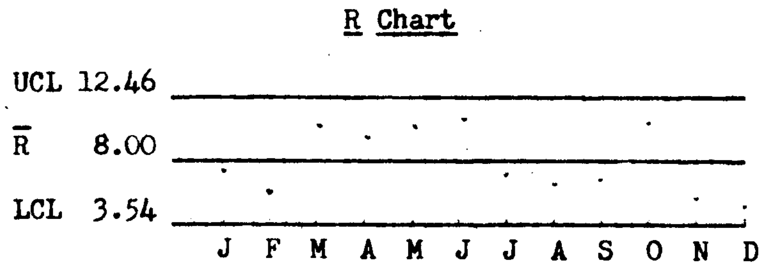


Figure 6-5 (Continued)



Five retrospective searches are chosen randomly every month, and a sample cost sheet is employed to accumulate all direct costs consumed for each unit. Figure 6-6 contains the hypothetical cost results registered during the year. The parameters of interest, $\bar{X}$ and R, are

Figure 6-6

Actual RSS Cost Samples for Control Purposes

Month	Sampled RSS Unit Costs					$\bar{X}$	R
January	$46.80	54.25	51.30	49.10	50.55	50.40	7.45
February	53.25	52.80	48.55	47.80	51.10	50.70	5.45
March	55.80	46.25	47.55	49.30	48.10	49.40	9.55
April	46.25	54.80	50.55	53.30	49.60	50.90	8.55
May	45.90	55.10	49.80	48.60	46.60	49.20	9.20
June	48.10	57.20	46.40	50.20	51.10	50.60	10.80
July	51.40	52.60	48.30	45.40	46.30	48.80	7.20
August	50.30	52.50	46.40	48.30	49.50	49.40	6.10
September	46.40	52.60	53.10	48.90	49.00	50.00	6.70
October	56.10	52.30	46.10	48.30	50.20	50.60	10.00
November	46.40	48.20	48.30	51.20	47.90	48.40	4.80
December	58.40	56.60	55.20	56.10	54.70	56.20	3.70

calculated for the monthly samples and are graphed on the control charts of Figure 6-5 to determine the control status of the direct search costs. During the first eleven months, the cost process is "in control" since all values fall within the acceptable ranges. Hence, the null hypothesis that the direct search costs compare favorably with the predetermined targets for $\bar{X}$ and R is accepted.

However, the average direct search cost for December is seen to exceed the acceptable upper control limit, thus indicating that the cost process is "out of control." The results suggest an upward shift in the average amount of direct costs consumed for the individual retrospective searches. Managerial action is required immediately to determine the cause of this deviation so that appropriate corrective action may be taken. Otherwise, the unfavorable cost variance will be detrimental to the breakeven objective of the NASA Regional Dissemination Center. Specific procedures for the necessary corrective action are discussed in the following section.

CORRECTIVE ACTION

Analysis of Cost Deviations

Several alternative courses of action are possible if a sample result is recorded outside the required probability limits. First, management must verify the values calculated for the sample cost parameters. Recording errors on the sample cost sheets or mathematical mistakes incurred during the processing phase may be the cause of the unsatisfactory results. In such cases, the cost process is not actually "out of control," and further investigation is not necessary.

Assuming that the data were registered and processed correctly, interviews with the employees responsible for the direct costs consumed on the sampled searches and a critical analysis of the recorded cost increments should be performed. Greater quantities of a particular cost input may have been utilized due to such factors as a change in the nature of the service, a planned deviation in the production process, or an inefficient search operation. Also, the unit cost of a resource (for example, computer time) may have changed during the period. Hopefully, the sample data will provide a sufficient amount of detail for this type of evaluation.

If the cause of the unfavorable cost results can be ascertained from the sample information, management must decide upon an appropriate solution. When the deviation merely reflects chance error that infrequently will occur within prescribed probability limits, the cost targets should be maintained as representative figures. For example, with $k = 1.5$, random error should cause sample results outside the control limits approximately 13 per cent of the time. However, if the number of times a given parameter falls outside the acceptable range exceeds the predicted amount, chance error is highly unlikely. Such investigations represent the costs incurred to reduce β, the probability of a Type II error.

When the unsatisfactory results are attributable to an employee's performance in the production process, corrective action should be taken to improve the inefficient operation. However, if the analysis exposes a permanent and legitimate change in the direct search costs consumed on the individual units, the representative values or targets must be revised accordingly. The dynamic nature of an information retrieval process undoubtedly will demand such modifications as new and improved searching methods are discovered. The statistical cost model adjusts to the alterations automatically by maintaining control over the process parameters on a continuing basis.

In some cases, the sample information may not reveal adequately the nature of the change. Management can overcome this problem by reinstating the proposed formal cost accounting system and utilizing it for a temporary period. The formal accounting procedure will provide cost information for every search performed during the selected duration so management will have a more complete description of the production process. Once the reasons underlying the unfavorable deviations are resolved, the revised cost targets can be applied to the $\bar{X}$ and R charts for continued statistical cost control. The "start-up costs" of the formal cost accounting system are minute so its temporary application offers an efficient way to obtain more detailed information.

Summary

The statistical cost control model provides a systematic verification of the direct search costs. Predetermined targets are established as a measure of management's objectives, and two control charts are employed to detect any deviation from the standards. The $\bar{X}$ chart indicates the behavior of the central tendency of the search cost data as it is related to certain probabilistic control limits. The R chart provides a confirmation of the status of the search process cost dispersion. Five searches are selected monthly for both information services, and a sample cost sheet is utilized to collect the direct costs consumed for each unit. Whenever an unfavorable variance is observed for one of the sample parameters, managerial action is necessary to investigate the causal factors. As long as the sample values of the mean cost and cost range are within the predetermined control limits, management is assured with a probabilistic reliability that the process costs are "in control." Therefore, the objective of management by exception is accomplished, and a NASA Regional Dissemination Center possesses an efficient cost control technique.

CHAPTER 7

SUMMARY AND CONCLUSIONS

INTRODUCTION

A serious deficiency of managerial cost information in technical information centers was discovered during the initial stage of this study. The consensus of statements by authorities found in the literature review (Chapter 2) and the results of the research questionnaire survey (Exhibit II) show a need for accurate cost data but indicate that cost estimation practices normally are employed.

This study proposes a two-fold solution to provide management of a NASA Regional Dissemination Center with relevant cost information. A computerized managerial cost accounting system has been designed specifically for the two main services of a NASA Center, retrospective searching and maintaining current awareness. The system will generate reliable and timely managerial cost information. Once appropriate service cost targets are determined, a statistical cost model can be employed in lieu of the formal cost accounting system and will provide an efficient and economical cost control technique.

ESSENTIAL FEATURES - MANAGERIAL COST ACCOUNTING

Basic Assumptions

Certain basic assumptions are necessary to design a practical cost accounting system for a NASA Center. The following list represents a summary of the essential assumptions employed in this study.

1. A center possesses a computer capability for the data processing function.

2. A center is concerned with information management which is defined as the receipt, storage, retrieval, reproduction, dissemination, and inventory control of information.

3. It is reasonable and necessary to require the engineers to record their daily work activity. The objective of the daily increment is to achieve a balance between realistic cost data and a preoccupation with minute detail.

4. A center possesses a financial accounting system for such functions as payroll, purchasing, accounts receivable, and accounts payable.

5. Service cost data and the quality of the information produced must be evaluated concurrently by management for an operating performance efficiency measurement.

6. Fixed labor costs are discretionary expenditures and can be altered only during the planning phase of the operation.

7. A retrospective search is a unique unit as it progresses through the production process.

8. The Selective Dissemination Service must be accounted for on a process costing basis since minutely detailed source information reporting would be required if the costs related to each profile search were measured.

9. The cost of an individual profile search is a linear function of the number of abstracts identified during the computer run.

10. The distribution of the multi-dimensional variables affecting the unit search costs remains relatively constant during a short interval (for example, three months).

11. General RSS costs consumed directly for the service rather than individual searches must be accumulated and averaged over the related retrospective searches.

12. Maintenance expenses for both information services must be applied to the individual searches with an estimated rate to minimize the possibility of volatile unit costs.

13. The SDS development expenses represent an asset to a center and must be amortized over the related profile's expected life.

14. Management of a center can forecast a reasonable estimate of the normal operating capacity.

15. A client's demand for an information service is relatively insensitive to the product's price.

16. RSS computer costs must be batched during a monthly period and distributed to the related searches on an average basis to minimize the possibility of volatile unit costs.

Fundamental Characteristics

The objective of the managerial cost accounting system is the generation of relevant information for planning, controlling, and decision-making purposes. The information searching process is viewed as a production operation, and the cost system accumulates cost data as the various jobs are performed. Responsibility accounting and service costing are achieved concurrently since the expenditures are charged to the appropriate cost center and information service. A job order costing method is employed to record the costs consumed for a retrospective search as it progresses through the production process. Since the Selective Dissemination Service contains relatively homogeneous production units, a process costing technique is utilized to calculate weighted-average profile charges for each SDS performance.

The cost system consists of a collection of source documents, forms, records, computer printouts, and managerial reports that are designed expressly for a NASA Regional Dissemination Center's operation. An electronic computer performs most of the essential operations of the system's data processing function, and the necessary computer programs are presented in the Appendicies of this study. The employees responsible for the various work activities record the consumed cost increments on the appropriate source documents during the information searching operation to provide the basic cost data for the electronic data processing function.

The direct labor data (recorded in hours) are transferred to a punched card for weekly computer processing, and a labor performance printout (Appendix I) is generated to indicate a complete classification of the work increments performed by each employee in the various cost centers. This report provides valuable managerial information for planning, controlling, performance evaluation, and workload scheduling as explained in Chapter 3. The direct sundry expenses (computer time, telephone calls, reproduction costs, and travel) are processed by the computer at the end of each month and reported on a cost performance printout. The labor hours shown on the weekly reports are reclassified as the related direct labor costs by the computer on the monthly printout. A predetermined operations overhead rate, selected from the normal capacity of a flexible budget, is recorded on a control punched card so the computer calculates the appropriate share of operation overhead for each service on the basis of the direct labor cost.

The result is a monthly computer printout that discloses the period cost performance of the NASA Center, classified by cost center and information service. The cost performance printout provides essential information for updating the records of the cost accounting ledger, for performing the managerial reporting function, and for general managerial applications as explained in Chapter 3. The exact nature of the procedures employed to record and process the cost data depends on the type of costing technique used for a specific information service.

Retrospective Search Service. Each retrospective search is costed as a unique production unit, and a job order number is assigned to each search when it is initiated. All direct costs consumed during a search's production as well as the related operations overhead are charged to the appropriate job order number. Additional RSS expenses which are traceable only to the overall retrospective search system must be averaged over the number of searches performed during the period. RSS maintenance expenses also are incurred to update the information file and are charged to the searches on the basis of a predetermined rate to minimize the possibility of volatile unit costs. The result of the RSS costing procedure is a job order cost sheet (Exhibit XV) that contains a detailed classification of all expenditures charged to a given retrospective search. The accounting procedures used to record and process the various RSS expenses and to compute realistic unit costs are described in Chapter 4.

Selective Dissemination Service. A process costing technique is used to account for the operational costs of the profile searches performed for the Selective Dissemination Service. Otherwise, minutely detailed reporting by the employees responsible for the work activities would be necessary since small cost increments often are incurred for the individual profiles and the same abstracts may be evaluated for more than one profile. The operational costs incurred during each SDS performance are charged to the related service number and are averaged over the various profile searches. A weighted-average distribution is performed by the computer on the basis of the relative number of abstracts identified for each profile as explained in Chapter 5.

Nonoperational expenses are incurred for the Selective Dissemination Service's development and maintenance functions. Profile development costs represent an asset to the center since they benefit future profile searches. The expenses are amortized over the expected profile life so a portion is charged to each search. SDS maintenance costs are accounted for in a manner analogous to those of the Retrospective Search Service. A predetermined rate is selected from the ratio of the forecast SDS maintenance costs to the number of profile searches at normal capacity and is charged to each search. The data processing mechanics necessary for the calculation of a unit profile cost—consisting of a share of the operational, development, and maintenance expenses—are discussed in Chapter 5.

ESSENTIAL FEATURES - STATISTICAL COST CONTROL

Once reliable service cost data are available, management may choose to utilize a statistical cost control model instead of formal cost accounting procedures. The statistical cost model developed in Chapter 6 provides a continuous verification of the control status of the direct service costs consumed during the information search process. Representative values of the direct search cost mean and range are established as the targets of the statistical model for both information services, retrospective search and selective dissemination. The $\bar{X}$ chart measures the behavior of the central tendency of the service cost data, and the R chart is used to control the dispersion between the unit charges.

The null hypothesis which is tested is that the search costs are "in control" when compared with the representative values of $\bar{X}$ and R. Probabilistic control limits are established by comparing the costs of a Type I error in the test of hypothesis with those of a Type II error. Once the appropriate control limits are established, the chance of random error causing a rejection of a true hypothesis can be determined from the conditions of a normal probability distribution.

Five searches are selected randomly every month from both information services, and the direct costs consumed for each sample element are recorded on a single cost sheet as the jobs progress through the production process. The sample mean and range are computed for both services and registered on the appropriate statistical control chart. If the values fall within the acceptable limits, the hypothesis that the search costs are "in control" is accepted, and no further action is necessary. If a sample parameter is recorded outside the acceptable limits, the null hypothesis is rejected, and the search cost process is determined to be "out of control" when compared with the representative values. Managerial action is required to investigate the cause of the adverse results and to take corrective action which may include revising the service cost targets.

TEST PERIOD COST RESULTS

Test of the System

The proposed managerial cost accounting system was operated at the Aerospace Research Applications Center during the period July 1 - September 30, 1967 to test its effectiveness in accounting for the services of a NASA Regional Dissemination Center. The results of the test period were very favorable as described below and indicate that the system functions effectively in a NASA Center. The estimated cost of performing the data processing functions for the period was only $244.15 for both the automated and manual operations as described in Chapter 3. Relevant and timely cost information was generated for both services, retrospective search and selective dissemination, with a minimal amount of human inputs. The three computer programs presented in the Appendicies provided the necessary operating instructions for the data processing function, and after a "debugging" process performed effectively. The comparison of the monthly average search costs was extremely favorable, as measured by an analysis of variance model.

Samples of sizes 20 and 25 were selected each month from the unit service costs generated for retrospective searches and current awareness (profile) searches, respectively. The amount of direct labor, direct sundry expenses, and operations overhead recorded via the cost system is included in the unit cost figures. A complete listing of the sample results and the calculations of the analysis of variance tests are presented in Exhibit III.

The monthly average search costs also are shown in Figure 7-1. The null hypothesis, which has been tested with the analysis of variance model, is that the monthly average cost of each information service is approximately equal from month to month, subject only to random error.

Figure 7-1

Test Period Average Search Cost Results

	July	August	September
Average Retrospective Search	$85.17	$86.13	$86.87
Average Profile Search	7.46	7.22	7.28

If the cost accounting system functions effectively and the distribution of the multi-dimensional variables affecting the unit search cost remains relatively constant, the null hypothesis will be true.

Analysis of Variance

The results of the analysis of variance tests confirm the null hypothesis since the monthly average search costs of both services, RSS and SDS, were significantly equal during the test period. The mean retrospective search only varied by $1.60 during the three months (representing a 1.9% change), and the average profile search cost deviated $.24 between months (a 3.2% variation). A significance level of .05 was selected for the "F" ratio in the analysis of variance model, thus defining the critical regions for the two tests. The results of the analysis of variance tests are summarized in Figure 7-2.

The calculated "F" values for the cost data generated by the cost system were substantially lower than the critical regions for both services, indicating that the mean search costs were significantly equal from month to month. When the mean costs being tested are approximately

Figure 7-2

Comparison of "F" Test Values

	Actual "F" Value Calculated	Critical Region for Rejection
Retrospective Searches	.096	3.17
Profile Searches	.029	3.13

equal, an "F" ratio of about one can be expected. The significance of the equality of the monthly average search costs is derived from the fact that the "F" ratios for the Retrospective Search Service and the Selective Dissemination Service were only .096 and .029, respectively. The reasons for the low "F" ratios were the relatively small mean square-between groups which validate the hypothesis that the mean costs were significantly equal. Therefore, the null hypothesis is accepted, and the proposed managerial cost accounting system, on the basis of the limited application, functions effectively in a NASA Regional Dissemination Center.

DIRECTIONS FOR FUTURE RESEARCH

General Nature

The cost accounting and statistical cost systems developed in this study represent "pioneering" applications of cost measurement techniques in a technical information center. The results of this study should be extended through future research to enlarge the domain of information retrieval cost accounting practices. The present study provides an insight into a complex problem, and the need for future investigation is apparent. While a consensus of technical information center authorities supports the need for relevant managerial cost data in a center's operation, few cost systems presently are employed in such functions. Future research should be performed to investigate the critical problems discovered but left unsolved during this study so that valid cost measurement procedures will become routine in managing a technical information center. The purpose of this final section is to suggest some directions for future research that were discovered during the development of the proposed cost systems.

General Applicability

The most obvious limitation of this study is that the two cost systems have been designed specifically for the NASA Regional Dissemination Centers which represent a small segment of the total information processing operations in existence today. Future studies should be performed to answer the general question: "How applicable are the proposed cost systems for other information processing operations?" Other technical information centers produce the same type of services as those offered in the NASA Program, and in addition some centers perform the information selection, indexing, and abstracting functions. Also, various kinds of library operations offer information processing services which are similar to those of a technical information center.

Since the two cost systems represent cost measurement techniques designed expressly for an information production process, they offer potential applications to a broad category of information operations. While a distinguishing feature of a NASA Regional Dissemination Center is that cost data are required for pricing the services to clientele, other non-revenue generating functions should find the cost information beneficial for keeping the resource inputs commensurate with the benefits obtained. Future research should be performed to test the applicability of the cost systems proposed in this study in other information processing operations.

Information Benefit Index

Another serious problem discovered in this study is the lack of a reliable measuring device for the benefits derived by clientele from an information search. The uncertainty related to the quality of the production output constrains the utilization of cost data as a measure of operating efficiency. An evaluation of information service quality should be accomplished concurrently with a comparison of actual and budgeted costs for a realistic operating performance efficiency analysis.

Future research should be performed to develop a benefit index which can be used for an objective evaluation of the quality of an information search. Such an index could be related to the cost performance data to determine the efficiency and effectiveness of the operation. Such factors as the following should be investigated as possible inputs to a benefit index: (1) the relevancy of the information identified for a specific request; (2) the time required for the information search process; (3) the amount of relevant information identified in a center's own file in relation to that discovered from all sources; (4) the number of information sources available to the literature searcher for the request; (5) the importance to the client of a request satisfied by the results of the search; (6) the ease of accessibility for the client to the information retrieval system; (7) any direct applications of the information identified during the search; (8) the efficiency with which past search experiences regarding similar requests are utilized; (9) any new research ideas generated from the search; (10) the qualifications of the literature searcher in relation to the requested subject.

Economic Justification Studies

Future studies should be conducted to evaluate the validity of a technical information center operation. If reliable cost data are available and future research develops an objective information benefit index, a quantitative measure of a center's value will be possible. In the past, qualitative analysis has dominated any validity evaluations because of the lack of reliable information regarding the cost-benefit relationship. The value of the information which the system delivers and the cost of the performance can be analyzed concurrently if the quantitative data are available.

Intervening Variable Index

Future research also is necessary to develop an index that will measure the intervening variables which affect a given search. Such factors as the following appear to influence the unit cost of an information search: (1) the complexity of the problem; (2) the amount of relevant information available; (3) the size of the information file; (4) the past experience of the literature searcher with the subject; (5) the number of searches performed on a given computer run. Further studies should be performed to establish a complete list of the variables which affect the unit search cost, to define a theoretically sound unit of measure for each, and to weight each factor according to its importance in the process. An appropriate index should provide a beneficial managerial tool because of its hypothesized correlation with actual search costs and should facilitate the prediction of future search costs.

Operational Standards

Many of the nonengineering labor functions of a NASA Regional Dissemination Center are routine tasks and should be suitable for the application of standard measurements. Examples are such operations as document and abstract reproduction, microfiche preparation, literature filing, photocopying, and other repetitive clerical tasks. Standardization of the literature searching operation appears unrealistic due to the uncertainty of the variables that affect a given search. Variation is an inherent characteristic of the literature searching process so any attempt to measure deviations between actual and standard time would be meaningless. However, the routine tasks are similar to many repetitive jobs in a typical manufacturing operation, and the use of quantity and cost standards provides an effective cost control technique. Future studies are necessary to investigate methods for determining realistic standard measurements for the nonengineering phases of the information production process.

CONCLUSIONS

The major conclusions of this study are that objective managerial cost accounting practices such as those developed in the preceding chapters are both possible and essential in the operation of a technical information center. The importance of the findings is derived from an analysis of the contributions of relevant cost information which is available when one of the two cost systems is employed. A technical information center's operation is highly analogous to that of a typical business firm in which management is dependent on reliable cost information for effective planning, controlling, and decision-making.

An efficient operation is mandatory for a successful performance in the highly competitive business world. Quantitative data provide the most realistic basis for the measurement of an organization's objectives and performance. Without accurate production cost information, management is constrained in the execution of such functions as unit cost determination, budgeting, performance evaluation, pricing, product line analysis, cost control, coordination of the various functions, and quantitative decisions concerning alternative actions. The information deficiency condition contributes significantly toward an inefficient organization which operates at a competitive disadvantage.

Managements of technical information centers have been handicapped in the past, however, by the lack of relevant cost information related to the information searching activities. Since the volume and complexity of scientific and technical information is causing the institution of an increasing number of centers, the field of information retrieval is becoming more competitive, both for the attraction of customers and for the receipt of operating funds. An efficient operation, benefiting from valid service cost data, will be in an advantageous position since its prices will be lower than those of an inefficient center that struggles to maintain a breakeven revenue level by charging the excess costs to the customers. Also, funding agencies are experiencing more demands for their resources with the increasing number of centers so they undoubtedly will sort out the efficient operations as the most effective applications of the money.

Consequently, past practices of treating an information processing operation's expenses as overhead costs of the funding agency no longer are feasible, and accurate cost measurement is essential. The change from an overhead consideration to a service costing process will be beneficial to the stability of an information center since one of the findings of the literature review of this study is that financing as an overhead item presents a precarious position. When the sponsoring agency (for example, a business firm, governmental agency, or university) experiences a "monetary squeeze," the information processing operation is affected adversely since overhead functions normally are the easiest to reduce or eliminate.

Performance budgeting also will be possible with reliable cost data. At the present time, experience and judgement dominate the establishment of budgeted figures in a technical information center since valid cost data are not available. Cost measurement with one of the two systems presented in this study will enable management to project historical cost data to expected future service activity which will provide an objective basis for the budgeting process. Performance budgeting can be achieved with the cost data since the operating costs are related objectively to the work activity. Whether the center charges for the services it renders or is funded by a supporting body, performance budgeting will provide a realistic view of the operation's financial needs.

If management of a technical information center decides that a sustained utilization of a formal cost accounting system is unrealistic because of an excessively-burdensome reporting effort by the employees, the statistical cost model offers an efficient and economical cost control device. A minimal amount of cost consumption reporting is required since only samples of the information searches are considered. Thus, relevant managerial cost information can be obtained in a technical information center through the use of the formal cost accounting system, the statistical cost control model, or some combination of the two.

APPENDIX I

COMPUTER PROGRAM AND INSTRUCTIONS FOR THE ELECTRONIC DATA PROCESSING FUNCTION IN A NASA REGIONAL DISSEMINATION CENTER

APPENDIX I

COMPUTERIZED DATA PROCESSING OPERATING INSTRUCTIONS

I. Keypunch Form

The information recorded on the daily time tickets by the operating personnel is transferred to the keypunch form. The form presents the source information collected during the production process in an arrangement suitable for keypunching. The following information is required on each form:

Man No. (Number) - a three digit identification number is assigned to each employee. The first integer discloses the appropriate cost center in which the work is performed and the last two digits identify the specific person.

Ent. (Entry Type) - one of two numbers is recorded in this field:

3 - indicates regular time reporting card
2 - indicates correction card

Date - date that individual time ticket is completed in the form of year-month-day.

Job Code - recorded as two alphabetic letters followed by a four digit number. The two letters reveal the type of information service performed and the numbers identify the specific unit. For example, RS 1440 identifies a particular retrospective search. (See coding system in this Appendix.)

*The terms "Time Card Audit" and "Weekly Labor Performance Report" are synonymous as are the terms "Labor Cost Report" and "Monthly Cost Performance Report."

APPENDIX I (Continued)

Act. (Activity)	-	reveals the nature of the work activity performed on a given job.
Hours	-	indicates the labor time spent on the individual work increments. The time is reported in quarter hour increments which are shown as decimal figures, (for example, $2\frac{1}{2}$ hours is recorded as 0250).
Number of entries per line	-	up to five jobs per employee can be recorded on each line of the form. If a person works on more than five jobs, extra lines are used for the same individual.

II. Keypunch Process

The information on the keypunch form is punched onto cards which are used as an input to a CDC 3600 program which performs certain checking functions.

III. Weekly Labor Performance Report (Time Card Audit)

After sorting, a printout is generated by a computer run which lists all of the jobs performed by each employee during the weekly period.

IV. Correction Procedure

The printout is checked by the accounting function to insure that the data are correct. Any necessary corrections or additions are recorded on a second keypunch form. An entry can be made on the second form to delete any information recorded on the original keypunch form. The corrections are initiated as follows:

APPENDIX I (Continued)

(1) The same information that was entered originally for a transaction but which must be changed is recorded on a second keypunch form with the exception of the entry type which is now 2 instead of 3. This information is entered in the first set of fields of the form.

(2) The revised data are recorded in the correct way in the second set of fields. The computer will remove the original entry from the audit report and register the revised information.

(3) If the original information should be eliminated entirely, the procedure in (1) above is utilized but the second set of fields is left blank.

V. Monthly Cost Performance Report

At the end of the month, all other cost information (for example, supplies, travel, phone calls, and computer time), is recorded on the same keypunch form as that used for labor and is keypunched onto cards. The cost information is coded with a number that is used in the Man No. column, and the cost units are entered in the same column in which labor hours are recorded. These data are incorporated with the labor information collected on the time audit during the month (stored in the card file) and run on the computer to generate a monthly cost performance report. The control card code is 2 instead of 1 for the printout of the final weekly labor performance report as well as the monthly cost performance report. The latter report reveals all cost increments of the various information services performed during the month.

APPENDIX I (Continued)

VI. Punched Card Handling Instructions

1. Punched cards are prepared as the keypunch forms are received from the accounting function.
2. The cards are filed until all those pertaining to the monthly period are punched.
3. When all of the time cards for the month are punched, proceed as follows:
   (a) Sort time cards on columns 5-10, starting on column 10.
   (b) Place NAME CARD deck with sorted time cards.
   (c) Sort the combined decks on columns 1-4, starting in column 4. The cards are now ready for the first computer run.
4. Prepare control card according to the CONTROL CARD FORMAT sheet.
5. Submit job for computer run.
6. Send printed output to the accounting function. File cards in the temporary work file.

When correction sheets are received from the accounting function, proceed as follows:

1. Punch correction cards.
2. Sort corrections on columns 5-10. (Normally only columns 9 and 10 need be sorted as 5-8 will be identical in all cards.)
3. Place correction cards with previously run name cards and time cards and sort on columns 1-4.
4. Prepare control card according to CONTROL CARD FORMAT SHEET for second running.
5. Submit for computer run.

APPENDIX I (Continued)

6. Send printed output to the accounting function.

7. Sort cards on column 4. Save name cards (1 in column 4). Time cards and correction cards may be destroyed at the end of <u>next</u> month.

NOTE: WHEN SORTING, ALWAYS BEGIN IN THE HIGHEST NUMBERED COLUMN GIVEN.

APPENDIX I (Continued)

Keypunch Instructions

For: COST REPORTING SYSTEM

Source Document: COST SYSTEM KEYPUNCH FORM

COLUMNS	MODE	DATA
1-3	Numeric	Man Number
4	Numeric	Ent. - entry code (2 or 3 only)
5-10	Numeric	Date (YR-MO-DAY)
11-12	Alpha	Job Category
13-16	Numeric	Job Code Number
17	Alpha	Activity Code
18-21	Numeric	Time (18-19, hours; 20-21, decimal) Punch leading zeroes whether they are on the keypunch form or not.
22-32 33-43 44-54 55-65	)	Same as 11-21
66-80	Skip	

APPENDIX I (Continued)

LABOR REPORTING EXAMPLE

Man No. 104

(a) On June 4, 1967, he worked ½ hour on SDS #12 and 3 hours on RSS #2144.

(b) On June 2, 1967, he made a 15 minute phone call pertaining to RSS #2144.

(c) On June 8, 1967, he worked a total of 6 hours on jobs RSS #2144, SDS #12, SDS #13, Operations overhead and SDS #11.

Man No. 106

(a) On June 1, 1967, worked 8 hours on SDS #10.

Man No. 405

(a) On June 1, 2, and 3, 1967, spent 8 hours each day on administrative work.

A.R.A.C. TIME REPORTING SYSTEM
KEYPUNCH FORM

MAN NO. (1)	ENT (4)	DATE YR (5)	DATE MO	DATE DAY (10)	JOB CODE (11, 13)	ACT (17)	HOURS HR (18)	HOURS QTR	JOB CODE (22, 24)	ACT (28)	HOURS HR (29)	HOURS QTR	JOB CODE (33, 35)	ACT (39)	HOURS HR (40)	HOURS QTR	JOB CODE (44, 46)	ACT (50)	HOURS HR (51)	HOURS QTR	JOB CODE (55, 57)	ACT (61)	HOURS HR (62)	HOURS QTR
104	3	67	06	04	SD 12		00	50	RS 2144		03	00												
104	3	67	06	02	RS 2144	P	00	25																
104	3	67	06	08	RS 2144		01	75	SD 12		02	00	SD 13		01	50	OP		00	50	SD 11		00	25
106	3	67	06	01	SD 10		08	00																
405	3	67	06	01	AD		08	00																
405	3	67	06	02	AD		08	00																
405	3	67	06	03	AD		08	00																

NORMAL LABOR REPORTING ILLUSTRATION

APPENDIX I (Continued)

CORRECTION LABOR REPORTING EXAMPLE

Man No. 106

The AUDIT list contained an entry showing him having worked June 1, 1967, for one hour on SDS #10. If that entry were judged to be incorrect, the example shown will completely delete it from the records.

Man No. 203

The AUDIT list showed him having spent 2 hours on RSS #3616 on June 7, 1967. The entry shown will correct this to $2\frac{1}{2}$ hours.

Man No. 308

The AUDIT list indicates he worked on June 12, 1967, for 1 hour on OP 6. The entry shown will change this to OP 2.

A.R.A.C. TIME REPORTING SYSTEM
KEYPUNCH FORM

MAN NO. (1)	ENT (4)	DATE YR (5)	DATE MO	DATE DAY (10)	JOB CODE (11–13)	ACT (17)	HOURS HR (18)	HOURS QTR	JOB CODE (22–24)	ACT (28)	HOURS HR (29)	HOURS QTR	JOB CODE (33–35)	ACT (39)	HOURS HR (40)	HOURS QTR	JOB CODE (44–46)	ACT (50)	HOURS HR (51)	HOURS QTR	JOB CODE (55–57)	ACT (61)	HOURS HR (62)	HOURS QTR
106	2	67	07	01	SD 10		01	00																
203	2	67	07	07	RS 3616		02	00	RS 3616		02	50												
308	2	67	07	12	OP 6		01	00	OP 2		01	00												

CORRECTION LABOR REPORTING ILLUSTRATION

APPENDIX I (Continued)

CONTROL CARD FORMAT

Column	Data
1	Control Code. "1" - only the Weekly Labor Performance Report is run. This code is used when time cards for a given month are run for the first time (without corrections). "2" - both the Weekly Labor and the Monthly Cost Performance Report is run. This code is used when the time cards for a given month are run for the second time (with corrections).
2 - 17	Month and year, e.g., January, 1967.

APPENDIX I (Continued)

JOB CATEGORY

OPERATIONS OVERHEAD CONTROL CARD

Some job categories do not have operations overhead applied to them since they represent overhead costs. This card indicates which categories do and do not have overhead applied.

All legitimate Job Categories, e.g., SD, RS, OP, etc., must be indicated in this card. Up to twenty-five categories may be represented. Each category is represented by its two-character code, as used by Accounting, followed by an "N" if no overhead is to be calculated or a "Y" if overhead is to be calculated.

Column	Data
1-2	Job Category
3	Overhead indicator "N" - do not calculate overhead "Y" - calculate overhead
4-75	The same sequence is repeated up through column 75.

Each time a new job category code is utilized by the accounting function, it must be reflected in this card. If it is not, an ILLEGAL JOB CATEGORY message will appear in the AUDIT list.

APPENDIX I (Continued)

SECTION OVERHEAD RATE CARD FORMAT

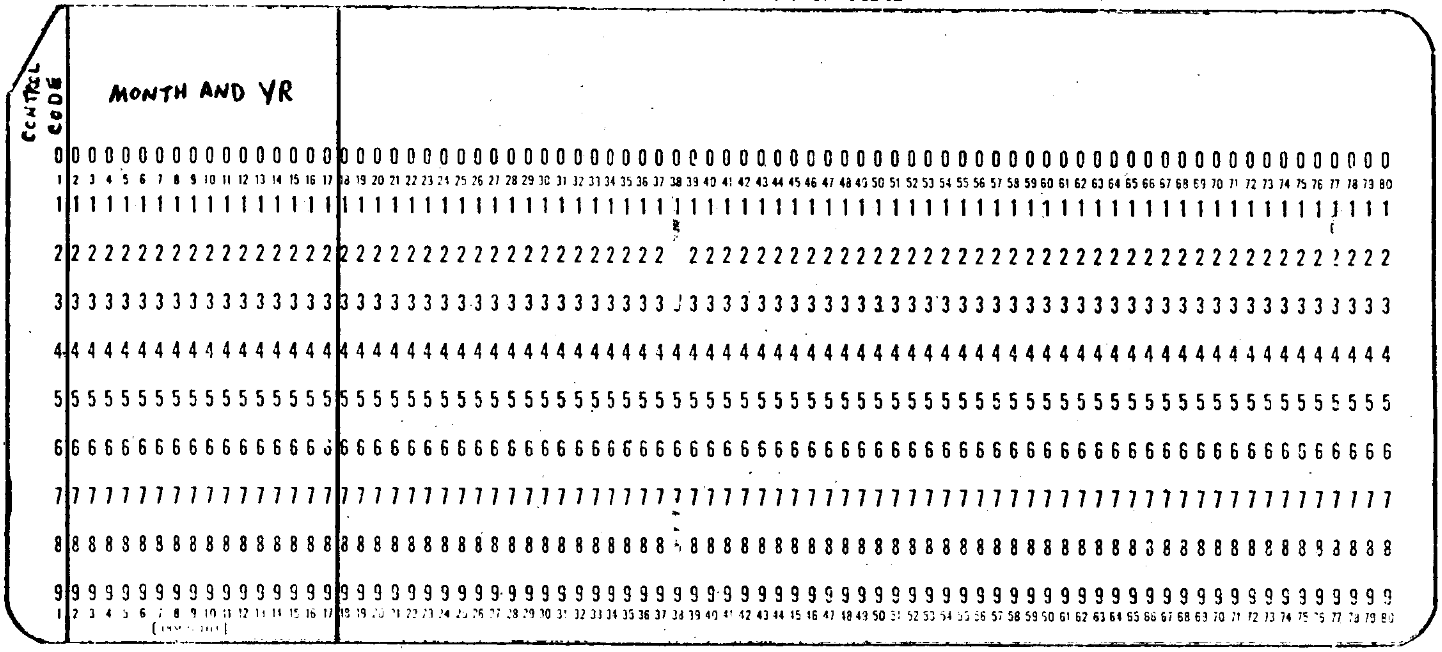
These cards carry the rate at which overhead is to be applied to the various cost centers. Overhead is applied on the basis of direct labor dollar cost.

Nine sections may have overhead rates. Blank cards must be included with the pack, if there are fewer than nine sections, for a total of nine cards.

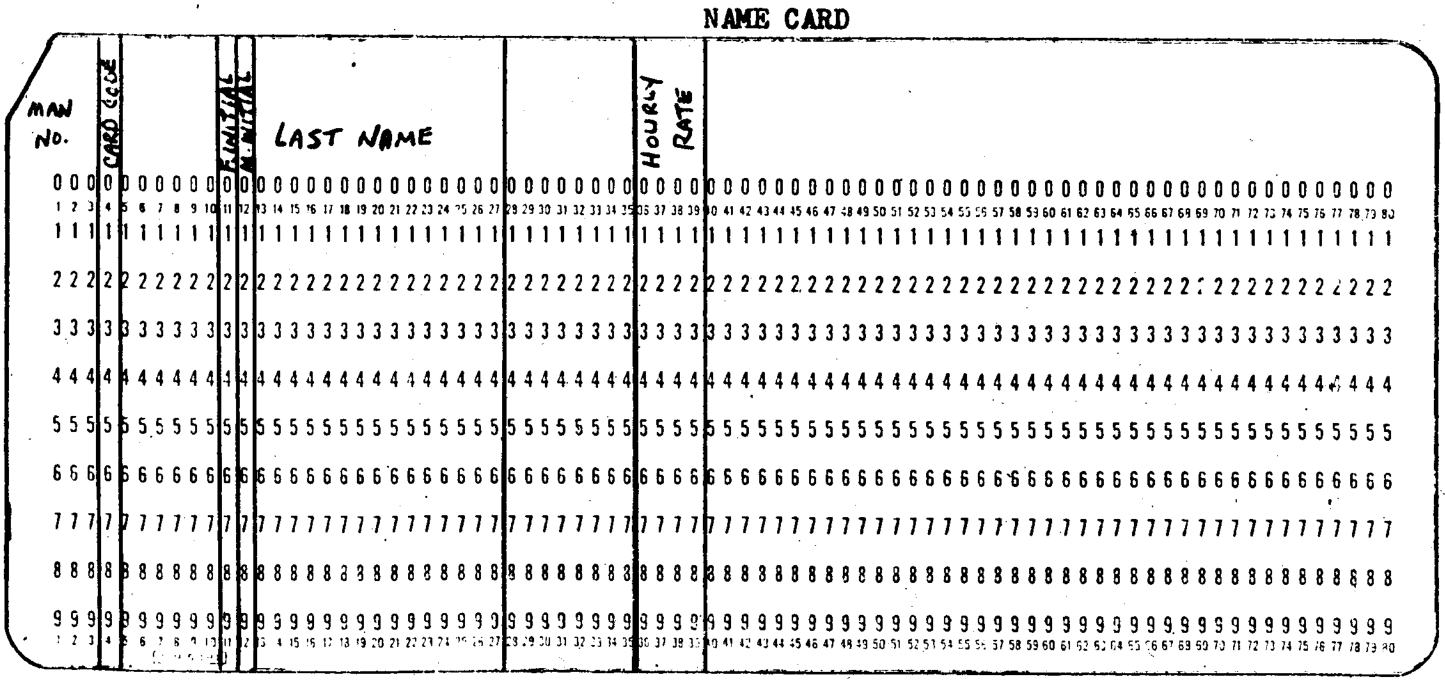
Column	Data
1	Cost center number 1 - engineers 2 - clerical 3 - service 4 - computer 5 - administrative
4	Card code - "0" (zero)
16-19	Overhead rate, e.g., $3.25 would be punched 0325.
20-25	Abbreviated name of section, e.g., ENGR - engineers.

CARD FORMAT FORM

PROGRAM CONTROL CARD 220



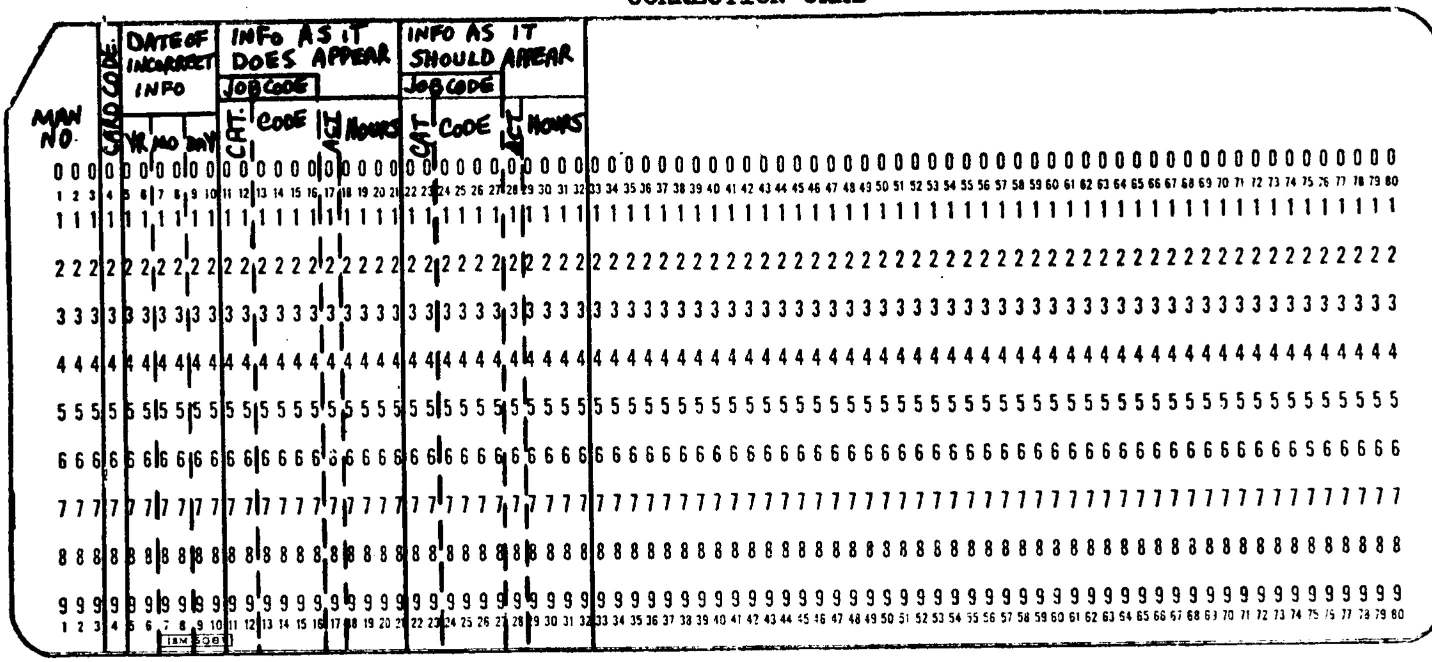
NAME CARD



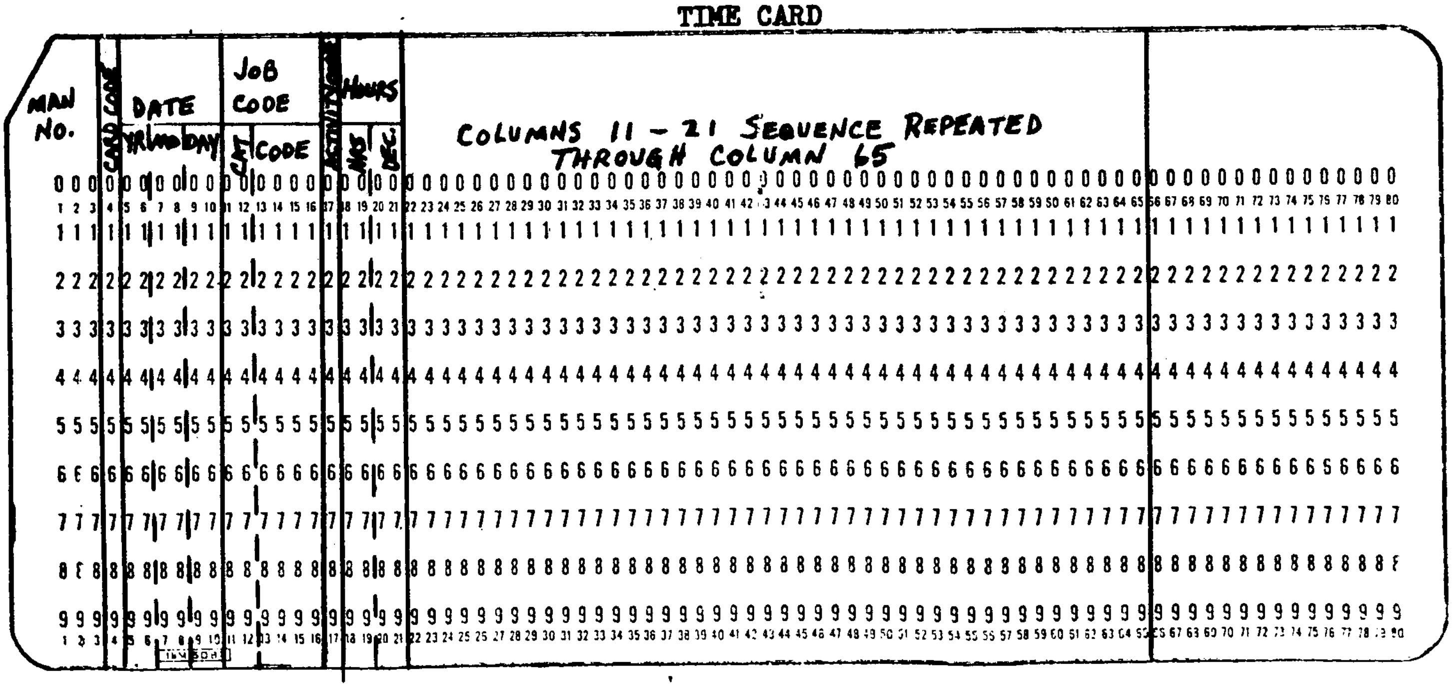
CARD FORMAT FORM

CORRECTION CARD

221

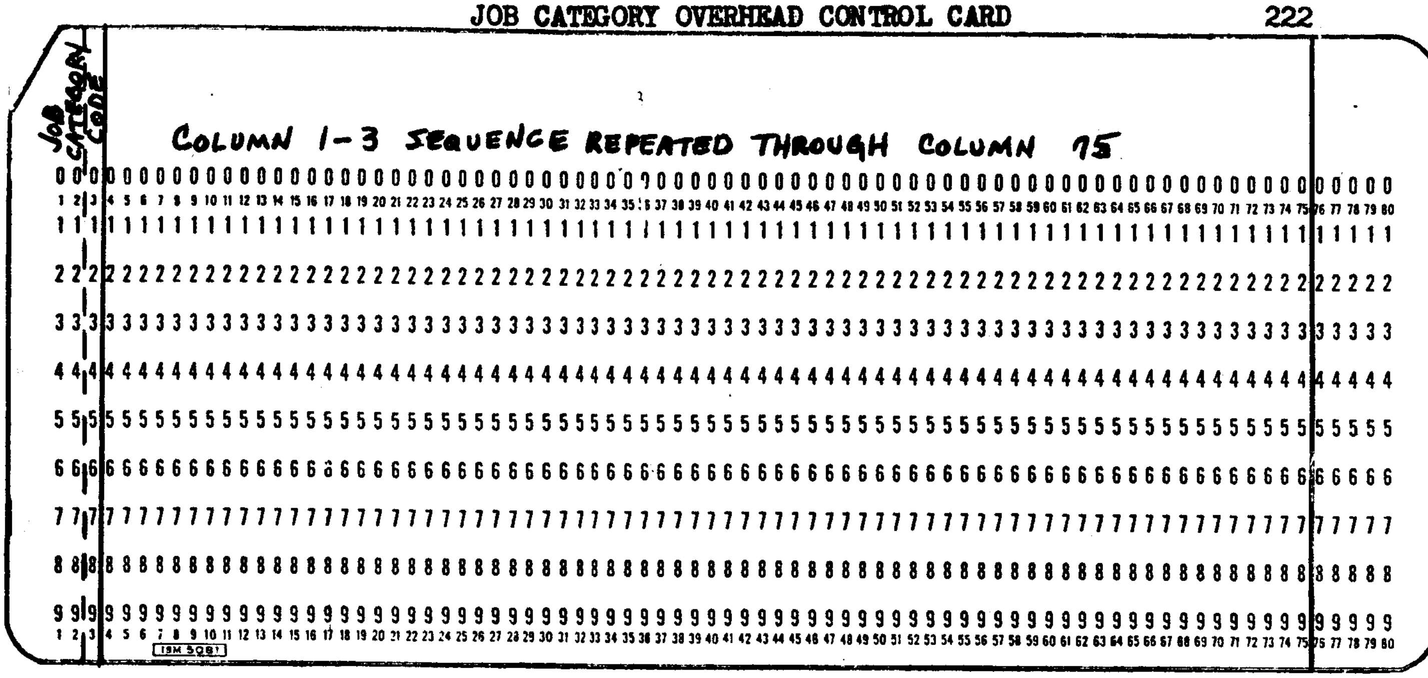


TIME CARD

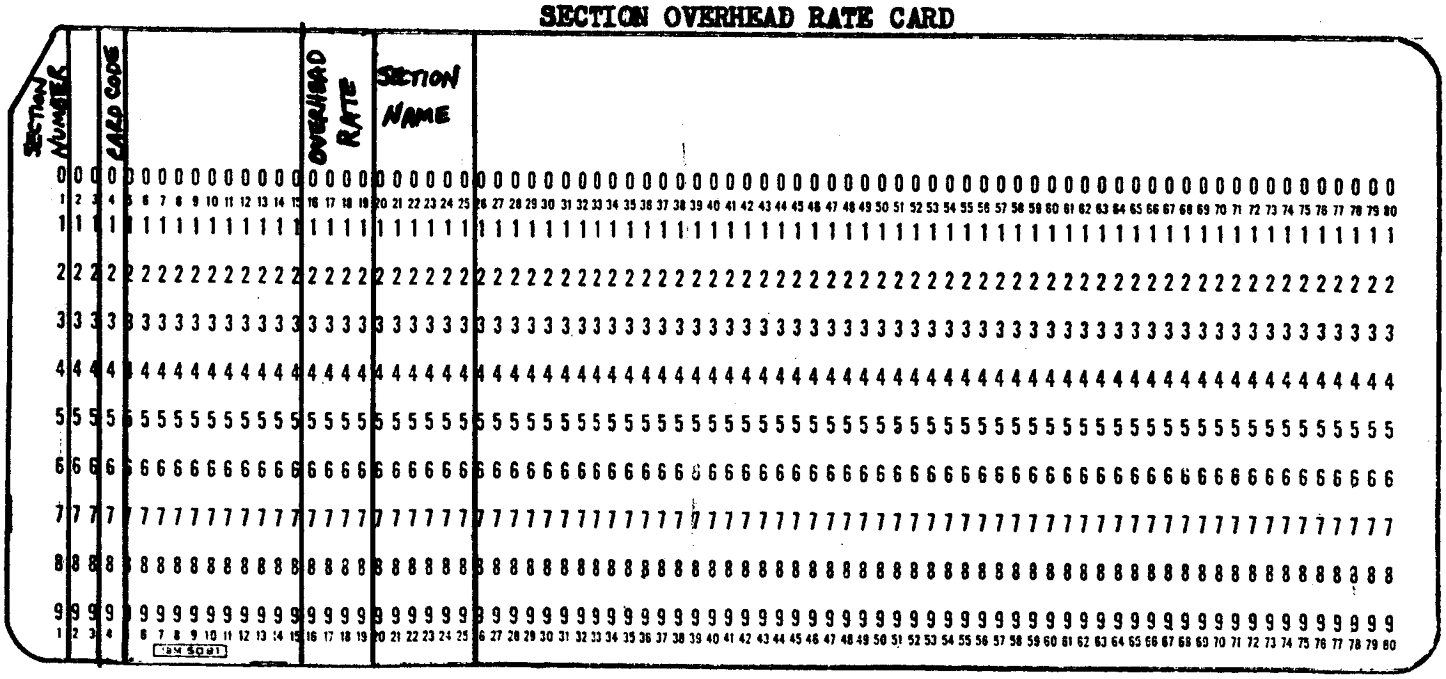


CARD FORMAT FORM

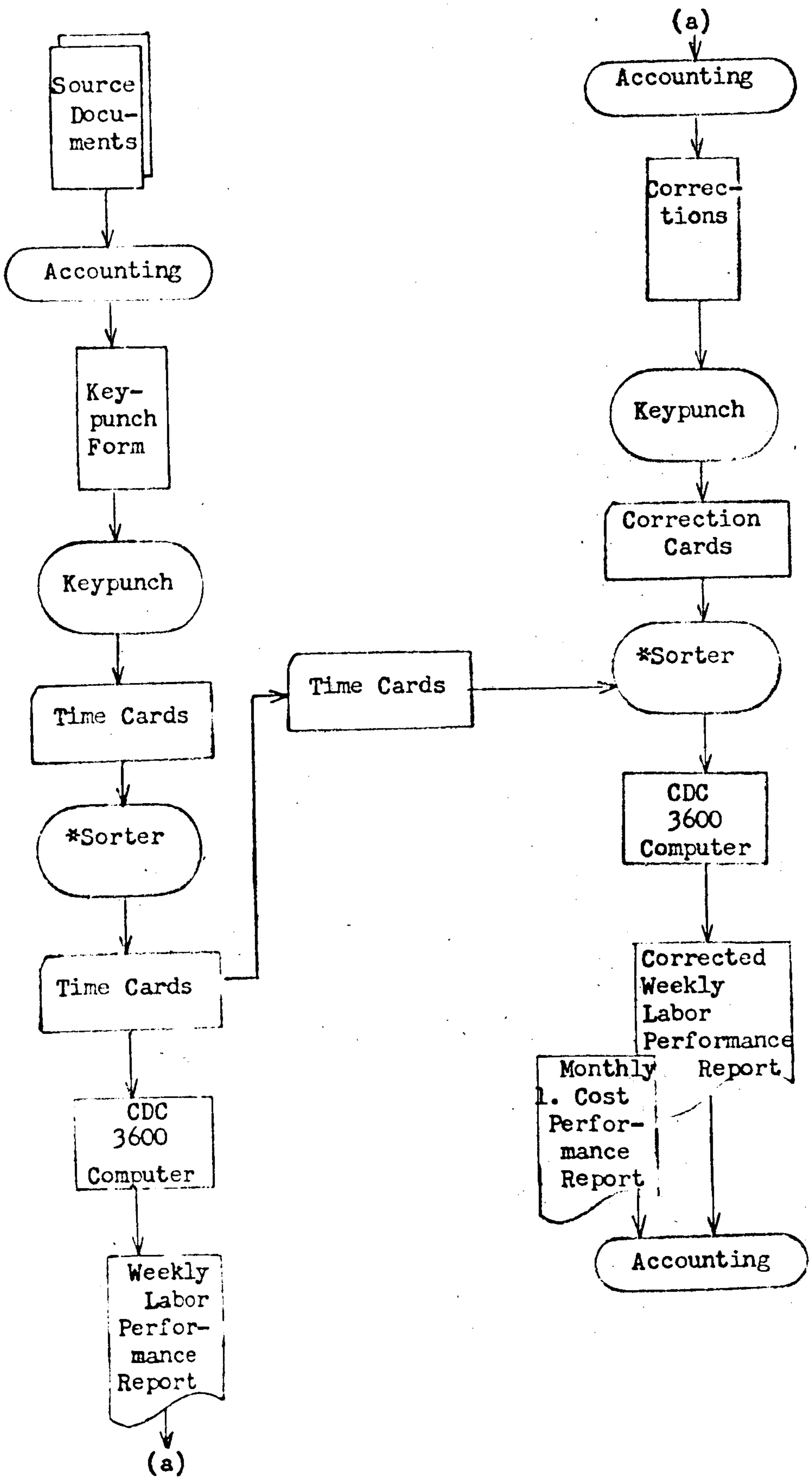
JOB CATEGORY OVERHEAD CONTROL CARD 222



SECTION OVERHEAD RATE CARD



COMPUTERIZED DATA PROCESSING SYSTEM FLOW CHART



*<u>Sequence</u>

Man No. - Major (Col. 1-3)
Card Code - Intermediate (Col. 4)
Date - Minor (Col. 5-10)

1. Change control card code to 2 instead of 1 for monthly cost performance report.

APPENDIX I (Continued)

REPORTING CODING SYSTEM

I. Direct Labor and Direct Sundry Expenses

100 - Engineering Cost Center*

200 - Clerical Cost Center*

300 - Reproduction Cost Center*

400 - Computer Cost Center*

*Last two digits identify specific employees.

500 - Materials - Supplies and Expenses Section

501 - Telephone

502 - Microfiche

503 - Photocopy

504 - Xerox

505 - Bruning Mats

506 - Bruning

507 - Computer Time

508 - Covers

509 - Depreciation

510 - Postage

511 - Company Travel

II. Work Activity Codes

OP - General Administrative Time

OP1 - Idle

OP2 - Break

OP3 - Clean

OP4 - Mail

OP5 - Meetings

OP6 - Library

APPENDIX I (Continued)

RS =	Retrospective Search Service - General
RSM	Retrospective Search Maintenance
RS (4 digits)	Retrospective Search with specific search number
SD = (or SDM)	Selective Dissemination Service Maintenance time
SD (2 digits)	Selective Dissemination Service with specific performance number
SDD (2 digits)	Interest Profile Development
SS 1 through 19	Special Projects

APPENDIX I

WEEKLY LABOR PERFORMANCE REPORT ILLUSTRATION

Month of July, 1967 — Time Card Audit — Page 1

Section	Man	Date	Job Activity	Hours
Engr	101	67/07/05	OP	2.00
	101	67/07/05	SD =	2.00
	101	67/07/05	RS 3399	1.25
	101	67/07/06	SD =	1.00
	101	67/07/06	OP	1.50
	101	67/07/08	SD =	1.00
	101	67/07/08	RS 3399	.50
	101	67/07/08	OP	2.50
	Man 101 Total			11.75

Engr 101 Service Category Totals

OP	6.00
SD	4.00
RS	1.75

Service Category Totals

OP	206.50
SD	413.50
RS	130.00
SS	140.25

Section Engr Totals 890.25

Section	Man	Date	Job Activity	Hours
Cler	201	67/07/12	OP 2	.50
	201	67/07/12	SD =	2.00
	201	67/07/12	SS 5	1.00
	201	67/07/14	SD 10	3.50
	201	67/07/14	OP 2	.50
	201	67/07/15	OP 2	.50
	201	67/07/15	SD 10	3.50
	201	67/07/16	SS 5	1.25
	Man 201 Total			12.75

Cler 201 Service Category Totals

OP	1.50
SD	9.00
SS	2.25

APPENDIX I (Continued)

Month of July, 1967 Time Card Audit Page 2

Section	Man	Date	Job Activity	Hours
Service Category Totals				
OP	110.00			
SD	49.50			
SS	15.25			
DO	125.00			
RS	51.25			
Section Cler Totals		351.00		
Srvice	302	67/07/03	OP 4	1.25
	302	67/07/03	OP 2	.50
	302	67/07/03	RS =	1.00
	302	67/07/05	RS =	4.00
	302	67/07/05	OP	1.00
	302	67/07/06	OP 2	.50
	302	67/07/06	SD =	1.50
	302	67/07/06	OP 4	1.50
Man 302 Total				11.25
Srvice 302 Service Category Totals				
OP	4.75			
RS	5.00			
SD	1.50			
Srvice Category Totals				
OP	375.25			
RS	126.75			
SD	174.25			
SS	210.25			
Section Srvice Totals		886.50		
Infsys	403	67/07/05	OP	2.25
	403	67/07/05	OP	5.00
	403	67/07/07	OP	7.00
	403	67/07/08	OP	6.25
	403	67/07/09	OP	4.25
	403	67/07/10	OP	6.50
	403	67/07/12	OP	5.50
	403	67/07/13	OP	8.00
Man 403 Total				44.75
Infsys 403 Service Category Total				
OP	44.00			

APPENDIX (Continued)

Month of July, 1967 | Time Card Audit | Page 3

Section	Man	Date	Job Activity	Hours

Service Category Totals

OP	160.00
SS	95.25
AD	21.00
RS	5.00

Section Infsys Totals 281.25

Section	Man	Date	Job Activity	Hours
Admin	501	67/07/01	SD =	15.00
	501	67/07/04	RS 3387	1.00
	501	67/07/04	RS 3415	1.00
	501	67/07/06	RS 3281	1.00
	501	67/07/08	RS 3410	4.00
	501	67/07/09	RS 3420	1.00
	501	67/07/09	RS 3427	7.00
	501	67/07/10	RS 3422	3.00

Man 501 Total 33.00

Admin 501 Service Category Totals

SD	15.00
RS	18.00

Service Category Totals

SD	45.52
RS	72.16
OP	88.75
DO	17.76
SS	231.14

Section Admin Totals 455.33

Service Category Grand Total

OP	878.25
SD	678.57
RS	397.41
SS	704.14
AD	21.00
CT	10.50
DO	161.54

Grand Total Hours Worked 2943.41

APPENDIX I (Continued)

MONTHLY COST PERFORMANCE REPORT ILLUTSTRATION

Month of July, 1967 — Monthly Job Labor Cost Report — Page 1

Job	Section	Man Act	Hours	Base Cost	Oper Ovhead	Cost With Oper Overhead
RS 3342	Engr	103	2.25	7.78	8.16	15.94
	Section Engr Total		2.25	7.78	8.16	15.94
RS 3342	Cler	203	0.50	0.85	0.89	1.74
		204	0.25	0.42	0.44	0.86
	Section Cler Total		.75	1.27	1.33	2.60
RS 3342	Srvice	315	0.75	2.59	2.71	5.30
	Section Srvice Total		0.75	2.59	2.71	5.30
RS 3342	Admin	504	.05	0.25		
	Section Admin Total		.05	.25		
**********	Job 3342 Total		3.80	11.89	12.20	24.09

Section Percentage of Jobs

Engr	62.8
Cler	11.4
Srvice	24.6
Admin	1.2

Job	Section	Man Act	Hours	Base Cost	Oper Ovhead	Cost With Oper Overhead
RS =	Engr	102	1.00	3.46	3.63	7.09
RS =	Engr	110	2.50	8.65	9.08	17.73
	Section Engr Total		3.50	12.11	12.71	24.82
RS =	Cler	203	3.75	6.41	6.73	13.14
RS =	Cler	204	33.00	65.34	68.60	133.94
	Section Cler Total		36.75	71.75	75.33	147.08
RS =	Srvice	302	5.00	7.50	7.87	15.37
	Srvice	303	.75	1.12	1.17	2.29
	Srvice	309	15.00	22.50	23.62	46.12
	Section Service Total		20.75	31.12	32.66	63.78
RS =	Infsys	407	4.75	8.31	8.72	17.03
	Section Infsys	407	4.75	8.31	8.72	17.03

APPENDIX I (Continued)

Month of July, 1967 — Monthly Job Labor Cost Report — Page 2

Job	Section	Man Act	Hours	Base Cost	Oper Ovhead	Cost With Oper Overhead
RS =	Admin	501	2.00	7.00		
RS	Admin	504	3.09	15.45		
RS =	Admin	507	5.00	1.05		
	Section Admin Total		10.09	23.50		
*****	Job RS Total		75.84	138.17	129.42	267.59

Section Percentage of Jobs

Engr	2.9
Cler	30.4
Srvice	54.3
Infsys	3.9
Admin	8.3

Total Cost By Section
For Job Category RS

	Base Cost	Oper Ovhead	Cost With Oper Overhead
Engr	477.39	501.03	978.42
Cler	98.67	103.51	202.18
Srvice	398.97	397.66	776.63
Infsys	8.74	9.17	17.91
Admin	275.35	0.00	275.35

Job	Section	Man Act	Hours	Base Cost	Oper Ovhead	Cost With Oper Overhead
SD 10	Engr	104	0.25	0.86	0.90	1.76
	Section Engr. Total		0.25	0.86	0.90	1.76
SD 10	Cler	201	3.75	6.86	7.20	14.06
	Section Cler Total		3.75	6.86	7.20	14.06
SD 10	Srvice	309	0.50	0.75	0.78	1.53
	Section Srvice Total		0.50	0.75	0.78	1.53
SD 10	Admin	504	0.04	0.20		
	Section Admin Total		0.04	0.20		
********	Job SD 10 Total		4.54	8.67	8.88	17.55

APPENDIX I (Continued)

Month of July, 1967		Monthly Job Labor Cost Report				Page 3
Job	Section	Man Act	Hours	Base Cost	Oper Ovhead	Cost With Oper Overhead
SD =	Engr	101	6.25	21.62	22.70	44.32
SD =	Engr	102	5.75	19.89	20.88	40.77
SD =	Engr	103	19.25	66.60	69.93	136.53
	Section Engr Total		31.25	108.11	113.51	221.62
SD =	Cler	201	27.75	50.78	53.31	104.09
SD =	Cler	203	5.75	9.83	10.32	20.15
	Section Cler Total		33.50	60.61	63.63	124.24
SD =	Srvice	302	3.75	5.62	5.90	11.52
SD =	Srvice	307	1.25	1.75	1.83	3.58
SD =	Srvice	309	0.50	0.75	0.78	1.53
	Section Srvice Total		5.50	9.12	8.51	17.63
SD =	Infsys	407	5.50	9.62	10.10	19.72
	Section Infsys Total		5.50	9.62	10.10	19.72
SD =	Admin	501	15.00	52.50		
SD =	Admin	504	2.22	11.10		
SD =	Admin	505	0.14	.73		
	Section Admin Total		17.36	64.33		
***********	Job SD = Total		93.11	250.79	195.85	446.64

Section Percentage of Jobs

Engr	65.5
Cler	15.0
Srvice	7.3
Infsys	2.4
Admin	9.5

Total Costs By Section
For Job Category SD

Engr	1406.52	1476.61	2883.13
Cler	88.90	93.32	182.22
Srvice	309.66	325.06	634.72
Infsys	9.62	10.10	19.72
Admin	106.44	0.00	106.44

APPENDIX I (Continued)

Month of July, 1967 Monthly Job Labor Cost Report Page 4

Job	Section	Man Act	Hours	Base Cost	Oper Ovhead	Cost With Oper Overhead
SS 3	Engr	101	1.50	5.19	5.44	10.63
SS 3	Engr	102	13.00	44.98	47.22	92.20
SS 3	Engr	103	9.25	32.00	33.60	65.60
	Section Engr Total		23.75	82.17	86.26	168.43
SS 3	Cler	203	4.50	7.69	8.07	15.76
	Section Cler Total		4.50	7.69	8.07	15.76
SS 3	Srvice	307	6.50	9.10	9.55	18.65
SS 3	Srvice	311	0.25	0.37	0.38	0.75
SS 3	Srvice	314	1.75	6.05	6.35	12.40
	Section Srvice Total		8.50	15.52	16.28	31.80
SS 3	Admin	505	5.47	28.71		
SS 3	Admin	507	79.70	16.73		
	Section Admin Total		85.17	45.44		
**********	Job SS Total		121.92	150.82	110.61	261.43

Section Percentage of Jobs

Engr	37.3
Cler	2.8
Srvice	5.4
Admin	54.3

Job	Section	Man Act	Hours	Base Cost	Oper Ovhead	Cost With Oper Overhead
SS =	Infsys	407	0.25	0.43	0.45	0.88
	Section Infsys Total		0.25	0.43	0.45	0.88
**********	Job SS = Total		0.25	0.43	0.45	0.88

Section Percentage of Jobs

Infsys	100.0

Total Costs By Section
For Job Category SS

	Base Cost	Oper Ovhead	Cost With Oper Overhead
Engr	499.95	524.86	1024.81
Cler	29.54	31.00	66.54
Srvice	370.97	389.43	760.40
Infsys	168.42	176.83	345.25
Admin	470.59	0.00	470.59

APPENDIX I (Continued)

Month of July, 1967 | Monthly Job Labor Cost Report | Page 5

Job	Section	Man Act	Hours	Base Cost	Oper Ovhead	Cost With Oper Overhead
	Engr		935.30			
	Cler		465.78			
	Srvice		1061.00			
	Infsys		228.25			
	Admin		964.10			
	Grand Total		3654.43	8646.04	4875.65	12,921.69

```
      PROGRAM TIME
      DIMENSION MSECT1(9)
      DIMENSION MSECT2(9)
      DATA(MSECT1=0,0,0,0,0,0,0,0,0)
      DATA(MSECT2=0,0,0,0,0,0,0,0,0)
      DIMENSION IALLS(9)
      DATA(IALLS=0,0,0,0,0,0,0,0,0)
      DIMENSION ICORS(50,20),ICAT(20,2),ICATALL(20,2)
      DIMENSION IREAD(41)
       DIMENSION JSECT(9),MSECT(9)
      DATA(JSECT=0,0,0,0,0,0,0,0,0)
      DATA(MSECT=0,0,0,0,0,0,0,0,0)
      DIMENSION ISA(4000,4)
      EQUIVALENCE(ICORS,ISAVE)
      DIMENSION ISAVE(200)
       DIMENSION ICRATE(52),NAMES(9),ICATF(20,2),ISRATE(9)
C CLEAR COUNTERS AND SET INITIALIZATION.
      IALL1=IALL2=IALL3=IALL4=0
      ASSIGN 7 TO NCARD
      DO 2750,I=1,4000
2750  ISA(I,1)=0
      DO 1008 , I=1,20
      ICATF(I,1)=ICATF(I,2)=0
1008   ICATALL(I,1)=ICATALL(I,2)=0
C CATEGORY RATE DETERMINATION CARD
      ISAV=1
      READ(60,2033)(ICRATE(I),I=1,52)
2033  FORMAT(26(R2,R1))
C SECTION RATE CARDS.
      DO 2034 I=1,9
      READ (60,2035) I1,I2,I3
 2035 FORMAT (I1,13X,I4,A6)
      ISRATE(I1) = I2
2034  NAMES(I1) = I3
      MZ=1
C READ DATE CARD
      READ(60,1)ICHECK,ID1,ID2
1     FORMAT(R1,2R8)
      ID3=8H             $ ID4=ID1  $ ID5=ID2
      IPAGE=0
      ICOUNT=60
      ISV2=ISV3=1
C READ FIRST NAME CARD
      READ(1,2)ISECTION,MANO,ICARD,MRATE
2     FORMAT(R1,R2,R1,31X,I4)
1011  ICORRECT=0 $ ASSIGN 12 TO ICOR $ ISV=ICKC=1
      DO 22, I=1,20
22    ICAT(I,1)=ICAT(I,2)=0
      JZ=MZ
      GO TO NCARD
C  READ CORRECTION OR TIME CARDS
7     READ(1,3)(IREAD(I),I=1,41)
3     FORMAT(R1,R2,R1,3R2,5(R2,R4,5R1))
      IF(EOF,1)1030,8
1030  IREAD(1)=1R9  $  GO TO 5
   8  DO 7000 I=10,38,7
```

```
      IF(IREAD(I) .EQ. 1R ) IREAD(I) = 0
      IF(IREAD(I+1) .EQ. 1R )IREAD(I+1)=0
      IF(IREAD(I+2) .EQ. 1R )IREAD(I+2)=0
      IF(IREAD(I+3) .EQ. 1R )IREAD(I+3)=0
 7000 CONTINUE
      IF (IREAD(3) .EQ. 2)4,5
C  SAVE CORRECTION CARDS
4     ICORRECT=ICORRECT+1   $  ASSIGN 11 TO ICOR
      DO 6, I=1,20
6     ICORS(ICORRECT,I)=IREAD(I)
      GO TO 7
C  TIME CARDS
5     IF((IREAD(1) .EQ. ISECTION).AND.(IREAD(2).EQ.MANO))9,1001
C  CHECK FOR CORRECTION CARD AND PRINT JOB LINE
9     DO 10, JJ=7,35,7
      IF(IREAD(JJ) .EQ. 2R  )7,1031
1031  GO TO ICOR
11    IF(ICORS(ICKC,6)-IREAD(6))2030,13,12
2030  WRITE(2,2031)(ICORS(ICKC,KX),KX=1,20)
2031  FORMAT(5X,5H*****,*CORRECTION CARD IN ERROR*,/5X,5H*****,R1,R2,R1,
     13R2,5(R2,R4,5R1),//)
      ICOUNT=ICOUNT+2
      ICKC=ICKC+1   $  IF(ICKC .GT. ICORRECT)2032,11
C CORRECTION CARD MUST AGREE EXACTLY WITH PRINTED OUTPUT OF FIRST RUN .
13    IF((ICORS(ICKC,7).EQ.IREAD(JJ)).AND.(ICORS(ICKC,8).EQ.IREAD(JJ+1))
     1)14,12
14    IF((ICORS(ICKC,9).EQ.IREAD(JJ+2)).AND.(ICORS(ICKC,10).EQ.IREAD(JJ+
     13)))15,12
15    IF((ICORS(ICKC,11).EQ.IREAD(JJ+4)).AND.(ICORS(ICKC,12).EQ.IREAD(JJ
     1+5)))16,12
16    IF(ICORS(ICKC,13).EQ.IREAD(JJ+6))17,12
C  ENTER CORRECTION
17    MM=JJ+6   $  LL=13
19    DO 18, KK=JJ,MM
      LL=LL+1
18    IREAD(KK)=ICORS(ICKC,LL)
      ICKC=ICKC+1
2032  IF(ICKC .GT. ICORRECT)ASSIGN 12 TO ICOR
C  EXTEND HOURS AND ACCUM TOTALS
      IF (ICORS(ICKC-1,14) .EQ. 2R  ) 10,12
12    LM=JJ+3   $  LK=JJ+6
      DO 1060,  KZ=LM,LK
      IF(IREAD(KZ).EQ. 1R )1061,1060
1061  IREAD(KZ)=0
1060  CONTINUE
      IHRS=(IREAD(JJ+3)*1000)+(IREAD(JJ+4)*100)+(IREAD(JJ+5)*10)+IREAD(J
     1J+6)+100
      ICOUNT=ICOUNT+1
      IF(ICOUNT-56)1020,1021,1021
1021  CALL HEADING(ID1,ID2,ID3,IPAGE,ICOUNT)
       NAME=ISECTION
1020  IHRS2=(IHRS-100)/100
      WRITE(2,20)NAMES(NAME),ISECTION,MANO,IREAD(4),IREAD(5),IREAD(6),
     1IREAD(JJ),IREAD(JJ+1),IREAD(JJ+2),IHRS2,IHRS
20    FORMAT(10X,A8,6X,R1,R2,4X,R2,2(1H/,R2),6X,R2,R4,5X,R1,7X,I2,1H.,I2
     1)
```

```
C SECTION NAME IS BLANK FOR ALL BUT THE FIRST LINE OF A PAGE.
      DO 8500, IXA=1,77,2
      IF(IREAD(JJ) .EQ. ICRATE(IXA))8501,8500
8500  CONTINUE
       WRITE(2,8502)IREAD(JJ)
8502  FORMAT(25X,*ILLEGAL JOB CATEGORY NO. *,R2)
      ICOUNT=ICOUNT+1
8501  NAME=9
C SAVE MAN-CATEGORY TOTALS
      DO 21, I=1,ISV
      IF(IREAD(JJ).EQ.ICAT(I,1))GO TO 23
21    CONTINUE
      ICAT(ISV,1)=IREAD(JJ)  $  ICAT(ISV,2)=IHRS-100
       ISV=ISV+1  $  GO TO 1070
C SAVE JOB CATEGORY AND JOB FOR THIS MAN
23    ICAT(I,2)=ICAT(I,2)+IHRS-100
1070  ISAV1=(IREAD(JJ)*10000000B)+IREAD(JJ+1)
      DO 1071, IZ=JZ,MZ
      IF(ISAV1 .EQ. ISA(IZ,1))1072,1071
1071  CONTINUE
C ISA SAVE AREA FOR MAN TOTALS BY JOB
      ISA(MZ,1)=ISAV1  $ ISA(MZ,2)=DRATE $ ISA(MZ,3)=IHRS-100
      ISA(MZ,4)=(ISECTION*10000B)+MANO $  MZ=MZ+1  $  GO TO 10
1072  ISA(IZ,3)=ISA(IZ,3)+IHRS-100
10    CONTINUE
      GO TO 7
C END OF TIME FOR THIS MAN
1001  ITOT=0
      DO 1002, I=1,ISV
1002  ITOT=ICAT(I,2)+ITOT
      ITOT2=ITOT/100
      ITOT=ITOT+100
      IF(ICOUNT .LT. 56)GO TO 8000
      CALL HEADING(ID1,ID2,ID3,IPAGE,ICOUNT)
8000  ICOUNT=ICOUNT+2
      WRITE(2,1003)ISECTION,MANO,ITOT2,ITOT
1003  FORMAT(1H0,10X,*MAN *,R1,R2,* TOTAL*,15(2H - ),I3,1H.,I2)
C  WRITE SERVICE CATEGORY TOTALS
      ICOUNT=ICOUNT+2
      IF(ICOUNT-56)1022,1023,1023
1023  CALL HEADING(ID1,ID2,ID3,IPAGE,ICOUNT)
1022   WRITE(2,1004)
1004   FORMAT(1H0,10X,*SERVICE CATEGORY TOTALS*)
      ISV=ISV-1
C WRITE CATEGORY TOTALS
      DO 1005, I=1,ISV
       IHRS=(ICAT(I,2)/100)
      IHRS2=ICAT(I,2)+100
      ICOUNT=ICOUNT+1
      IF(ICOUNT-56)1024,1025,1025
1025  CALL HEADING(ID1,ID2,ID3,IPAGE,ICOUNT)
1024   WRITE(2,1006)ICAT(I,1),IHRS,IHRS2
C SAVE CATEGORY TOTALS FOR THIS SECTION
1006   FORMAT(15X,R2,3X,I5,1H.,I2)
      DO 1007, II=1,ISV2
      IF(ICAT(I,1).EQ.ICATALL(II,1))GO TO 1009
```

```
1007  CONTINUE
      ICATALL(ISV2,2)=ICAT(I,2)
      ICATALL(ISV2,1)=ICAT(I,1)
      ISV2=ISV2+1   $   GO TO 1005
1009  ICATALL(II,2)=ICATALL(II,2)+ICAT(I,2)
1005   CONTINUE
      ICOUNT=ICOUNT+2
      WRITE(2,1050)
1050  FORMAT(1H0)
      IF(IREAD(1).EQ.ISECTION)1014,1010
C END OF SECTION.  WRITE SECTION TOTALS.
1010  ISV2=ISV2-1
      CALL HEADING(ID1,ID2,ID3,IPAGE,ICOUNT)
      WRITE(2,1004)
      ITOT=0
      DO 1012, I=1,ISV2
      ITOT=ICATALL(I,2)+ITOT
      IHRS=ICATALL(I,2)/100
      IHRS2=ICATALL(I,2)-100
C SAVE GRAND TOTALS
      DO 1052,  MK=1,ISV3
      IF(ICATF(MK,1).EQ. ICATALL(I,1))1053,1052
1052  CONTINUE
      ICATF(ISV3,1)=ICATALL(I,1) $ ICATF(ISV3,2)=ICATALL(I,2)
      ISV3=ISV3+1
      GO TO 1012
1053  ICATF(MK,2)=ICATF(MK,2)+ICATALL(I,2)
1012  WRITE(2,1006)ICATALL(I,1),IHRS,IHRS2
      IHRS=ITOT/100
       WRITE(2,1013)NAMES(ISECTION),IHRS,ITOT
1013  FORMAT(1H0,4X,*SECTION *,A8,*TOTALS*,3X,I5,1H.,I2,//)
      ICOUNT=60
       NAME=IREAD(1)
      DO 2752, MI=1,20
2752  ICATALL(MI,1)=ICATALL(MI,2)=0
      ISV2=1
C EOJ INDICATOR
      IF(IREAD(1) .EQ. 1R9)GO TO 1051
C
C  NAME CARD READ UNDER TIME CARD FORMAT.-- REFORMAT.
1014  ISECTION=IREAD(1)  $  MANO=IREAD(2)  $  ICARD=IREAD(3)
      NAME=ISECTION
      IF(ICARD .NE. 1)GO TO 2500
      DECODE(3,1015,IREAD(22))MRATE
1015  FORMAT(5X,I3)
      IF(IREAD(23) .EQ. 1R )IREAD(23)=0
      MRATE=(MRATE*10)+IREAD(23)
      ASSIGN 7 TO NCARD
      GO TO 1011
2500  MRATE=0  $  WRITE(2,2501)
2501  FORMAT(5X,5H*****,*NAME CARD MISSING.*,/,5X,5H*****,*RATE IS SET T
     1O ZERO*)
       ASSIGN 8 TO NCARD  $  GO TO 1011
1051  CALL HEADING(ID1,ID2,ID3,IPAGE,ICOUNT)
C WRITE GRAND TOTALS
      ISV3=ISV3-1  $  ITOT=0
```

```
      DO 1054, I=1,ISV3
      IHRS=ICATF(I,2)/100
      WRITE(2,1006)ICATF(I,1),IHRS,ICATF(I,2)
1054  ITOT=ITOT+ICATF(I,2)
      ITOT2=ITOT/100
      WRITE(2,1055)ITOT2,ITOT
1055  FORMAT(1H0,9X,*GRAND TOTAL *,I5,1H.,I2)
C ICHECK INDICATOR FOR SECOND HALF OF PROGRAM (TIME CARD AUDIT)
C   (ARAC MONTHLY JOB LABOR REPORT)
      IF(ICHECK .EQ. 1)GO TO 6000
      DO 1100,I=1,200
1100  ISAVE(I)=0
      JZ=I=1  $  ND=0
C SAVE JOB NUMBERS FOR SORT
1104  DO 1101, K=1,I
      IF(ISAVE(K) .EQ. ISA(JZ,1))1102,1101
1101  CONTINUE
      ISAVE(I)=ISA(JZ,1)  $  I=I+1
1102  JZ=JZ+1
      IF(JZ .EQ. MZ)1103,1104
C  SORT JOBS INTO ALPHA ORDER.
1103   ICOUNT=60
      IPAGE=0
      IJ1=IJ2=0
      IJC1=IJC2=IJS1=IJS2=0
      IJS3=IJS4=IJ3=IJ4=IJC3=IJC4=0
      KM=1
      CALL SORT(ISAVE(1),ISAVE(I-1),1,1,0,0)
C JOB CATEGORY
2026  JOBC=ISAVE(KM)/10000000B
C CATEGORY RATE DETERMINATION
      DO 2036, IX=1,51,2
      IF(JOBC .EQ. ICRATE(IX))2037,2036
2036  CONTINUE
      WRITE(2,2038)JOBC
2038  FORMAT(1H0,10(8H********),/,3X,*JOB CATEGORY ERROR *,R2,/)
      ICOUNT=ICOUNT+2
      IX=51
2037  IFIRST=0
C SCAN SAVE AREA FOR ALL ENTRIES FOR THIS JOB
2016   DO 2000, LL=1,MZ
      IF(ISA(LL,1).EQ.ISAVE(KM))2001,2012
2001  IF(IFIRST .EQ. 0)2002,2003
2002  ISVSECT=ISA(LL,4)/10000B
      IFIRST=1
2003  IF(ISVSECT .EQ. (ISA(LL,4)/10000B))2004,2008
C CALCULATE LINE TOTAL
2004  MCOST=(ISA(LL,2)*ISA(LL,3))/100
      IJS1=IJS1+ISA(LL,3) $ IJS2=IJS2+MCOST
      IALL1=IALL1+ISA(LL,3)
      MCOST2=MCOST/100
      IHRS2=ISA(LL,3)/100
      ICOUNT=ICOUNT+1
C OVERHEAD RATE DETERMINATION
      IF(ISRATE(ISVSECT) .EQ. 0)GO TO 3000
      IF(ICRATE(IX+1) .NE. 1RY)3000,3001
```

```
3001  IOPH=(MCOST*ISRATE(ISVSECT))/100
      IOPH2=IOPH/100
      IOPW=IOPH+MCOST  $  IOPW2=IOPW/100
      IJS3=IJS3+IOPH  $  IJS4=IJS4+IOPW
      IF(ICOUNT .LT. 57)GO TO 3002
      CALL HEADM(ID4,ID5,IPAGE,ICOUNT)
3002  WRITE(2,3003)ISAVE(KM),NAMES(ISVSECT),ISA(LL,4),IHRS2,ISA(LL,3),
     1MCOST2,MCOST,IOPH2,IOPH,IOPW2,IOPW
3003  FORMAT(6X,R6,5X,A8,2X,R3,11X,I3,1H.,I2,I6,1H.,I2,I7,1H.,I2,6X,I6,
     11H.,I2)
      GO TO 2012
3000  IF(ICOUNT-57)2005,2006,2006
2006  CALL HEADM(ID4,ID5,IPAGE,ICOUNT)
2005  WRITE(2,2007)ISAVE(KM),NAMES(ISVSECT),ISA(LL,4),IHRS2,ISA(LL,3),
     1MCOST2,MCOST
2007  FORMAT(6X,R6,5X,A8,2X,R3,11X,I3,1H.,I2,I6,1H.,I2)
      IJS4=IJS4+MCOST
C HAVE I SCANNED  FULL AREA)
2012  IF(LL .EQ. MZ)2008,2000
2008  IHRS2=IJS1/100  $  MCOST2=IJS2/100
      ICOUNT=ICOUNT+2
C SAVE COUNTERS FOR END OF JOB, END OF RUN, AND END OR CATEGORY.
      JSECT(ISVSECT)=IJS1 +JSECT(ISVSECT)
      MSECT(ISVSECT)=MSECT(ISVSECT)+IJS2
      IJ3=IJ3+IJS3  $  IJ4=IJ4+IJS4
      MSECT1(ISVSECT)=MSECT1(ISVSECT)+IJS3
      MSECT2(ISVSECT)=MSECT2(ISVSECT)+IJS4
      IF((ICRATE(IX+1).NE. 1RY).OR.(ISRATE(ISVSECT) .EQ. 0))3005,3004
3004  IOPH=IJS3/100  $  IOPH2=IJS4/100
      IF(ICOUNT-60)3006,3007,3007
3007  CALL HEADM(ID4,ID5,IPAGE,ICOUNT)
      ICOUNT=ICOUNT+2
C WRITE SECTION TOTALS
3006  WRITE(2,3008)NAMES(ISVSECT),IHRS2,IJS1,MCOST2,IJS2,IOPH,IJS3,
     1IOPH2,IJS4
3008  FORMAT(1H0,14X,*SECTION *,A6,* TOTAL*,5X,I4,1H.,I2,I6,1H.,I2,I7,
     11H.,I2,6X,I6,1H.,I2)
      GO TO 3009
3005  IF(ICOUNT-60)2009,2010,2010
2010   CALL HEADM(ID4,ID5,IPAGE,ICOUNT)
      ICOUNT=ICOUNT+2
2009  WRITE(2,2011)NAMES(ISVSECT),IHRS2,IJS1,MCOST2,IJS2
2011  FORMAT(1H0,14X,*SECTION *,A6,* TOTAL*,5X,I4,1H.,I2,I6,1H.,I2)
3009  IFIRST=0 $ IJ1=IJ1+IJS1 $ IJ2=IJ2+IJS2 $ IJS1=IJS2=0
      IJS3=IJS4=0
      ISVSECT=ISA(LL,4)/10000B
      IF(LL .EQ. MZ)GO TO 2000
      WRITE(2,3055)
      ICOUNT=ICOUNT+1
      GO TO 2001
2000  CONTINUE
C WRITE JOB TOTALS
      IHRS2=IJ1/100  $  MCOST2=IJ2/100
      ICOUNT=ICOUNT+4
       IF(ICOUNT-60)2013,2014,2014
2014  CALL HEADM(ID4,ID5,IPAGE,ICOUNT)
```

```
      ICOUNT=ICOUNT+3
      IJC4=IJC4+IJ4
      IJC3=IJC3+IJ3
 2013 IF(ICRATE(IX+1) .NE. 1RM)GO TO 3010
      WRITE(2,2015)ISAVE(KM),IHRS2,IJ1,MCOST2,IJ2
 2015 FORMAT(3X,20H*************** JOB ,R6,* TOTAL*,X,I8,1H.,I2,I6,1H.,
     1I2,//)
 3012 IJC1=IJC1+IJ1   $   IJC2=IJC2+IJ2
      WRITE(2,3020)
 3020 FORMAT(10X,*SECTION  PERCENTAGE OF JOBS*)
      ICOUNT=ICOUNT+1
C WRITE PERCENT OF JOB
      DO 3021, IB=1,9
      IF(JSECT(IB) .EQ. 0)GO TO 3021
      IALLS(IB)=IALLS(IB)+JSECT(IB)
      IPCT=(JSECT(IB)*1000)/IJ1
        IPCT2=IPCT/10
      ICOUNT=ICOUNT+1
      IF(ICOUNT-57)3040,3041,3041
 3041 CALL HEADM(ID4,ID5,IPAGE,ICOUNT)
 3040 WRITE(2,3022)NAMES(IB),IPCT2,IPCT
 3022 FORMAT(10X,A6,9X,I3,1H.,I1)
 3021 JSECT(IB)=0
      IJ1=IJ2=0
      WRITE(2,3055)
 3055  FORMAT(8H         )
      ICOUNT=ICOUNT+1
      KM=KM+1
      IF((ISAVE(KM)/100000000B) .EQ. JOBC)GO TO 2016
C  WRITE JOB CATEGORY TOTALS
      ICOUNT=ICOUNT+2
       IF(ICOUNT-57)3046,3045,3045
C WRITE TOTAL COST BY SECTIONS
 3045 CALL HEADM(ID4,ID5,IPAGE,ICOUNT)
 3046 WRITE(2,3023)JOBC
      ICOUNT=ICOUNT+1
 3023 FORMAT(15X,*TOTAL COSTS BY SECTION*,/,15X,*FOR JOB CATEGORY *,R2)
      DO 3024, IB=1,9
      IF(MSECT(IB) .EQ. 0)GO TO 3024
      IPCT=MSECT(IB)/100
      ICOUNT=ICOUNT+1
      IF(ICOUNT-57)3047,3048,3048
 3048 CALL HEADM(ID4,ID5,IPAGE,ICOUNT)
 3047 IALL2=IALL2+MSECT(IB)
      IPCT1=MSECT1(IB)/100   $   IALL3=IALL3+MSECT1(IB)
      IPCT2=MSECT2(IB)/100    $   IALL4=IALL4+MSECT2(IB)
      WRITE(2,3025)NAMES(IB),IPCT,MSECT(IB),IPCT1,MSECT1(IB),IPCT2,
     1MSECT2(IB)
 3025 FORMAT(20X,A6,19X,I6,1H.,I2,I7,1H.,I2,4X,I8,1H.,I2)
 3024  MSECT(IB)=MSECT1(IB)=MSECT2(IB)=0
      WRITE(2,7055)
 7055 FORMAT(10(8H********),//)
      ICOUNT=ICOUNT+2
      IJC1=IJC2=0
C END OF RUN CHECK
      IF(KM .EQ. I)2020,2026
```

```
2020  IPCT=IALL1/100 $ IPCT1=IALL2/100 $ IPCT2=IALL3/100
      IPCT3=IALL4/100
      CALL HEADM(ID4,ID5,IPAGE,ICOUNT)
C WRITE SECTION GRAND TOTALS
      DO 7060, I=1,9
      IF(IALLS(I) .EQ. 0)GO TO 7060
      IB=IALLS(I)/100
      WRITE(2,7061)NAMES(I),IB,IALLS(I)
7061  FORMAT(10X,A6,10X,I6,1H.,I2)
7060    CONTINUE
      WRITE(2,4000)IPCT,IALL1,IPCT1,IALL2,IPCT2,IALL3,IPCT3,IALL4
4000  FORMAT(16X,*GRAND TOTALS*,8X,I8,1H.,I2,I6,1H.,I2,I7,1H.,I2,
     14X,I8,1H.,I2)
6000  STOP
3010  IOPH=IJ3/100  $  IOPH2=IJ4/100
      ICOUNT=ICOUNT+1
      IF(ICOUNT-57)3049,3050,3050
3050  CALL HEADM(ID4,ID5,IPAGE,ICOUNT)
3049  WRITE(2,3011)ISAVE(KM),IHRS2,IJ1,MCOST2,IJ2,IOPH,IJ3,IOPH2,IJ4
3011  FORMAT(3X,20H*************** JOB ,R6,* TOTAL*,X,I8,1H.,I2,I6,1H.,
     1I2,I7,1H.,I2,6X,I6,1H.,I2,//)
      IJ3=IJ4=0  $  GO TO 3012
      END
```

```
      SUBROUTINE HEADING(ID1,ID2,ID3,IPAGE,ICOUNT)
      IPAGE=IPAGE+1
      WRITE(2,4)ID1,ID2,IPAGE
4     FORMAT(1H1,3X,*MONTH OF *,2R8,2X,*ARAC TIME CARD AUDIT*,
     110X,*PAGE*,I4,/,1H0,9X,*SECTION*,7X,*MAN*,6X,*DATE*,7X,*JOB*,4X,
     2*ACTIVITY*,4X,*HOURS*,//)
      ICOUNT=0
      RETURN
      END
```

```
      SUBROUTINE HEADM(ID4,ID5,IPAGE,ICOUNT)
       IPAGE=IPAGE+1
      ICOUNT=0
      WRITE(2,1)ID4,ID5,IPAGE
1     FORMAT(1H1,4X,*MONTH OF *,2A8,3X,*ARAC MONTHLY JOB LABOR COST REP
     1RT *,*PAGE*,X,I3,//,6X,*JOB*,8X,*SECTION*,3X,*MAN*,3X,*ACT*,5X,
     2*HOURS*,6X,*BASE*,5X,*OPER.*,7X,*COST WITH*,/,52X,*COST*,4X,
     3*OVHEAD*,6X,*OPER. OVHEAD*)
       RETURN
      END
```

APPENDIX II

COMPUTER PROGRAM AND INSTRUCTIONS FOR RECORDING COMPUTER TIME ACCORDING TO THE NATURE OF THE PERFORMANCE IN A NASA REGIONAL DISSEMINATION CENTER

APPENDIX II

INSTRUCTIONS FOR COMPUTER TIME ACCUMULATION

The following steps should be performed to record the amount and nature of the computer time utilized for a given performance:

Step 1. Read a card containing the following information:

(a) Identification number of the program being run using 6 positions.

(b) Cumulative total of time previously employed for this program in minutes using 8 positions (3 decimals).

(c) Rate per minute for the computer time using 5 positions (3 decimals).

(d) Cumulative cost total previously incurred by this program using 7 positions (2 decimals).

The field sizes can be altered to coincide with particular situations, and other information may be added as required by different NASA Centers..

Step 2. Call the internal computer clock and store the beginning time of the program in TIME IN (measured in milliseconds).

The two steps above should be executed at the beginning of the program. Next, the normal processing for which the main program is designed should be performed. At the conclusion of the normal computer performance, the following steps would be executed:

Step 3. Call the internal computer clock and store the ending time of the program in TIME OUT. Both TIME IN and TIME OUT are recorded in milliseconds.

Step 4. Calculate elapsed milliseconds (TIME OUT MINUS TIME IN), convert the figure to minutes (divide by 60,000), and store the result in TIME TOT.

APPENDIX II (Continued)

Step 5. Calculate the cost of this run (multiply TIME TOT by RATE) and store in COST.

Step 6. Update the cumulative time total of this program (ACCUMIN plus TIME TOT).

Step 7. Update the cumulative cost total of this program (ACCOST plus COST).

Step 8. Punch out a new, updated card as described in Step 1. The old card may be destroyed, and the new card will be the input to Step 1 during the next running of the program.

```
                      .
                      .
                      .
                      .
                 (NORMAL PROGRAM BEGINNING)
                      .
                      .
                      .
                      .
                      .
Step 1              READ 10, ID, ACCUMIN, RATE, ACCOST
              10    FORMAT (R6, F8.3, F5.3, F7.2)
Step 2              TIMEIN = TIMEF(X)
                      .
                      .
                      .
                      .
                 (NORMAL PROGRAM PROCESSING)
                      .
                      .
                      .
                      .
                      .
Step 3              TIMEOUT = TIMEF(X)
Step 4              TIMETOT = (TIMEOUT - TIMEIN) / 60000.
Step 5              COST = TIMETOT * RATE
Step 6              ACCUMIN = ACCUMIN + TIMETOT
Step 7              ACCOST = ACCOST + COST
Step 8              PUNCH 100, ID, ACCUMIN, RATE, ACCOST
             100    FORMAT(R6, F8.3, F5.3, F7.2)
                      .
                      .
                      .
                      .
                 (NORMAL END OF PROGRAM)
```

APPENDIX III

COMPUTER PROGRAM AND INSTRUCTIONS FOR SDS COST DISTRIBUTION TO THE INDIVIDUAL PROFILES IN A NASA REGIONAL DISSEMINATION CENTER

APPENDIX III

SDS OPERATIONAL COST DISTRIBUTION

The objective of the accompanying program is a weighted-average distribution of the total SDS operational costs incurred for a given SDS performance to the individual interest profiles. The computer calculates the unit profile charge on the basis of the relative profile pull. For example, if the total SDS operational costs are $4000.00 and a particular interest profile pulls 100 out of a total pull of 10,000, the unit charge would be $40.00. The computation is performed during the regular SDS computer search run.

Since the computer performs the calculation at the time the SDS search is run, the total operational costs are unknown. Instead, a cost breakdown of a range of possible costs is calculated, and the appropriate level is chosen after the correct process cost figure is known from the cost accounting system. At the present time, the costs are in increments of $200.00, ranging from $3200.00 to $5800.00.

Program Operation

Input
Program: COSTTEST
Input cards
SDS Distribution tape (Unit 1)

Output Printed Listing

Output listing forwarded to accounting function. Input stored for future use.

```
      PROGRAM COSTTEST
      DIMENSION S(301), ICODE(600),  ACC(600),NP(1),MC(600), ICOP(600)
      DIMENSION IN(2)
      EQUIVALENCE (INIT, DATE), (IN(2), AISSUE)
      TYPE INTEGER DATE ,AISSUE,S
      DO 10, I=1,600
10    ICODE(I) = ACC(I) = MC(I) = ICOP(I) = 0
      JIC = J = 1
      DOCTOT = 0
C  READ MULT COPY INTR COUNT
      READINPUTTAPE 60,50,NP
50    FORMAT(I4)
      WRITE(61,60) NP
60    FORMAT(1X,I4)
      J = 1
C  READ MULT COPY INTR CTR CARDS
80    READINPUTTAPE 60,81,S(1), S(2)
81    FORMAT(A8,I8)
      MC(J) = S(1) .AND. 7777777777B
      MC(J+1) = S(2)
      NP = NP-1
      WRITE(61,89) NP, S(1), S(2), MC(J), MC(J+1)
89    FORMAT(1X,I4,3X,A8,3X,I8,5X,A8,3X,I8,*NP,S,MC*)
00CCCC00000C0-1-88K+++400J2-++2J20080-K00-4+80J90+8004J8J8C0J0000000000
90    J = J+2
      GO TO 80
C  MARK END OF TABLE
100   MC(J+3) = 3HEND
      MC(J+4) = 8H
      J = 1
C  READ DATE AND ISSUE
200   BUFFER IN (4,1) (IN(1),IN(2))
210   IF(UNIT,4) 210,250,250,250
C  READ DISTRIBUTION TAPE
250   BUFFER IN (4,1) (S(1) , S(301))
251   IF( UNIT,4) 251,270,400,250
270   ICHK = S(1) .AND. 77777'00000B
      IF (ICHK .EQ. 5RXXX00) , GO TO 400
      IF (ICHK .EQ. 5RAAA00) GO TO 250
      ICODE(JIC) = S(1) .AND. 7777777777B
      ACC(JIC) = S(2)
      WRITE (61,279) S(1), S(2), ICODE(JIC), ACC(JIC)
279   FORMAT(10X,A8,3X,I8,5X,A8,3X,F8,*S, ICODE, ACC*)
280   IF (MC(J) .EQ. ICODE(JIC)) GO TO 300
      IF ( MC(J) .EQ. 3HEND) GO TO 350
      J = J+2
      GO TO 280
C  MULTIPLY PULL BY COPIES REQUIRED
300   AMC = MC(J+1)
      WRITE(61,305) AMC,MC(J+1), ACC(JIC)
305   FORMAT(1X,F8,3X,I8,3X,F8,*AMC,MC,ACC*)
C SET FOR CALC WITH MULT COPIES
      ACC(JIC) = ((ACC(JIC) * AMC)+ACC(JIC))/2.
      WRITE(61,320) ACC(JIC)
320   FORMAT(1X,F8,*ACC*)
      ICOP(JIC) = MC(J+1)
      JIC = JIC+1
C  SET FOR CALC WITHOUT  MULT COPIES
      ICODE(JIC) = S(1)
      ACC(JIC) = S(2)
```

```
      ICUP(JIC) = 2R**
350   DUCTOT = DOCTOT + S(2)
      J = 1
      JIC = JIC+1
      GO TO 250
C  MARK END OF NORMAL PROFILES
400   ICODE(JIC) = 5R77777
      JIC = JIC+1
C  READ DUMMY PROFILES
450   READINPUTTAPE 60,451,ICODE(JIC), ICUP(JIC), ACC(JIC)
451   FORMAT(A8,I2,F6)
      IF(EOF,60) 500,458
458   WRITE (61,459) ICODE(JIC), ICUP(JIC), ACC(JIC)
459   FORMAT(1X,A8,2X,I2,2X,F6,*ICODE, ICUP, ACC-DUMMY*)
      IF (ICUP(JIC) .EQ. 0 ) GO TO 480
      ACUP = ICUP(JIC)
      ACC(JIC) = ((ACC(JIC) * ACUP)+ACC(JIC))/2.
      WRITE(61,479) ACC(JIC), ACUP
479   FORMAT(1X,F8,2X,F8,*ACC, ACUP,-DUMMY*)
480   DOCTOT = DOCTOT + ACC(JIC)
      JIC = JIC+1
      GO TO 450
500   CALL COSTING (ICODE, ACC, DOCTOT, DATE, AISSUE, JIC, ICUP)
      STOP
      END
      SUBROUTINE COSTING (ICODE,  ACC, DOCTOT, DATE,AISSUE, JIC,ICUP)
      DIMENSION  COST(14),  CTOT(14),  TOT(14), ICODE(1),  ACC(1)
      DIMENSION ICUP(1)
      IPAGE=ILIM=ILINE=0
C   CLEAR ALL TOTAL AREAS
      DO 1999 I=1,14
1999  COST(I)=CTOT(I)=TOT(I)=0.
      CDOCS=0.
C  MARK  END O INTR CTR/DOC COUNT TABLE
      ICODE(JIC)  = 8H99999999
C  RESET INDEX TO START OF TABLE
      JIC = 1
      ICCK2 = ICODE  .AND. 77777700000B
C  WRITE REPORT HEADING
2000  IPAGE = IPAGE+1
      WRITE (61,2010) AISSUE, DATE, IPAGE
2010  FORMAT(1H1,*S.D.S. ISSUE NO.*, 1X,R2,25X,*A.R.A.C. INTEREST CENTE
     1 COST BREAKDOWN*,5X,*DATE*,1X,R8,5X,*PAGE*,1X,I2,//)
      WRITE(61,2012)
2012  FORMAT(1X,*I.C.*,6X,*TOT*,51X,*COST RANGE*)
      WRITE(61,2014)
C  IF THE LOW RANGE VALUE IN STATEMENT 2020 IS CHANGED, THIS FORMAT
C  MUST BE CHANGED TO REFLECT THE PROPER COLUMN HEADINGS.
2014  FORMAT(1X,*CODE*,1X,*CUP*,1X,*PULL*,3X,*3200*,4X,*3400*,4X,*3600*
     14X,*3800*,4X,*4000*,4X,*4200*,4X,*4400*,4X,*4600*,4X,*4800*,4X,
     2*5000*,4X,*5200*,4X,*5400*,4X,*5600*,4X,*5800*,//)
      ILINE = ILINE+7
C  INITIALIZE FIRST VALUE OF COST RANGE. VALUE WILL BE INCREMENTED IN
C  $200 STEPS TO $2600 ABOVE LOW VALUE. RANGE LIMITS MAY BE ALTERED BY
C  CHANGING THE LOW LIMIT VALUE IN THE NEXT CARD. (FLOATING POINT)
2020  RANGE = 3200.
C  CONVERT DOC COUNT + TOT DOCS TO FLOATING POINT
        FACTA =  ACC(JIC)
        FACTB =  DOCTOT
C  CALC INTR CTR DOCS AS PERCENT OF TOTAL PULL
```

```
      FACTOR =  FACTA /  FACTB
      CDOCS =  CDOCS +  ACC(JIC)
C  CALL INTR CTR COST AS PORTION OF RANGE VALUE
      ILIM=ILIM+1
 2050 COST(ILIM) =  FACTOR *  RANGE
C  UPDATE COMPANY TOTAL
      CTOT(ILIM) =  CTOT(ILIM) +  COST(ILIM)
C  UPDATE GRAND TOTAL
      TOT(ILIM) =  TOT(ILIM) +  COST(ILIM)
      ILIM = ILIM+1
C  CHECK END OF RANGE
      IF(ILIM .EQ. 15) GO TO 3000
      RANGE =  RANGE + 200.
      GO TO 2050
 3000 ILIM = 0
C  PRINT INTEREST CENTER BREAKDOWN LINE
      WRITE(61,3010) ICODE(JIC), ICOP(JIC), ACC(JIC), COST
3010  FORMAT(1X,R5,1X,R2,1X,F4,14(1X,F7.2),/)
      ILINE = ILINE+2
C  CLEAR INT CTR COST AREA
      DO 3015 I=1,14
      COST(I) = 0.
 3015 CONTINUE
      JIC = JIC+1
C  CHECK FOR NEW COMPANY
      ICCK1 = ICODE(JIC) .AND. 77777700000B
      IF (ICCK1 .EQ. ICCK2) GO TO 3050
C  PRINT COMPANY TOTAL
      WRITE(61,3030)  CDOCS,  CTOT
3030  FORMAT(1X,*TOT*,5X,F5.0,14(1X,F7.2),////)
      CDOCS=0.
      ILINE = ILINE+4
C  CLEAR COMPANY TOTAL AREA
      DO 3035 I=1,14
      CTOT(I) = 0.
 3035 CONTINUE
      ICCK2 = ICCK1
C  CHECK FOR END OF INT CTR TABLE. IF YES GO TO E-O-SUBROUTINE
3050  IF(ICODE(JIC) .EQ. 5R77777) GO TO 4000
3052  IF(ICODE(JIC) .EQ. 8H99999999) GO TO 5000
C  CHECK FOR PAGE LINE LIMIT
3070  IF(ILINE .LT. 50) GO TO 2020
      ILINE = 0
      GO TO 2000
4000  WRITE(61,4001)
4001  FORMAT(1H0,*FOLLOWING INTR. CTRS. SERVICED BY BLOCK PROFILES*)
      ILINE = ILINE+3
      JIC = JIC+1
      GO TO 3052
C
C  END OF SUBROUTINE
C
 5000 WRITE(61,5001)  DOCTOT,  TOT
5001  FORMAT(1H0,*GR TOT*,1X,F6,14(1X,F7.2))
      WRITE(61,5010)
 5010 FORMAT(1H1,1X)
      RETURN
      END
```

APPENDIX IV

EXHIBITS I - XVI USED IN THIS STUDY

EXHIBIT I

GLOSSARY OF TERMS USED IN THIS STUDY

1. Allocated cost - A cost that is charged to the information services on some indirect basis.

2. Chart of accounts - A list of the ledger accounts used in the accounting system.

3. Computer maintenance time - Computer time incurred to update the information file or refine an interest profile.

4. Controllable cost - A cost that can be directly regulated or influenced at a given level of authority.

5. Control ledger account - A general ledger account that is a summary record and is supported by a set of subsidiary ledger accounts.

6. Cost accounting journal - A chronological record of the financial transactions incurred during the information production process.

7. Cost accounting ledger - A record of every account established in the chart of accounts, representing the historical files of the financial transactions incurred during the information production process.

8. Cost accounting system - A formal communications network that produces relevant cost information for planning, controlling, and decision-making purposes.

9. Cost center - A responsibility unit (for example, a department or section) for which costs are accumulated.

10. Cost variance - A deviation between a cost target for a particular item and the actual cost recorded in the cost accounting system.

11. Direct cost - A cost item that is specifically and conveniently traceable to the information services.

12. Direct sundry expense - A term used to signify all direct costs except labor. Examples are computer time, telephone calls, reproduction expenses, and travel.

13. Discretionary costs - A cost that can be changed only during the planning phase, thus representing a fixed cost during the annual operation of a center.

14. Document - A complete scientific or technical report.

EXHIBIT I (Continued)

15. Engineer - A specialized literature searcher in a NASA Regional Dissemination Center.

16. Fixed cost - A cost which does not change in total for a given time period and service activity range but becomes progressively smaller on a per unit basis as volume increases.

17. Flexible overhead budget - A series of overhead budgets for varying service activity levels that adjust for the variable portion of the total operations overhead costs.

18. Full-cost pricing - A cost basis that contains an average amount of all service costs, both direct and indirect, and an allocated share of the selling and administrative expenses.

19. Gross margin - The revenue of a period less the cost of the services performed.

20. Indirect cost - A cost item that cannot be traced directly to an information service but is incurred in the production process.

21. Information - A general term which may refer to the contents of a complete document, an abstract of a document, or a reference to a document.

22. Information abstract - A summary of the essential features of a report or document.

23. Information citation - A reference to a report or document containing such information as the title, author's name, source, and number of pages.

24. Information management - The management of the receipt, storage, retrieval, reproduction, dissemination, and inventory control of scientific and technical information in a NASA Regional Dissemination Center.

25. Interest center - A synonym for the term "interest profile."

26. Interest profile - A listing of the relevant terms that describe a client's interest area and their relationship to each other.

27. Job order costing - A costing technique in which each search is considered a unique job, and the costs incurred during the production process are charged to the related searches.

28. Library - A general term used to define all library functions such as those operated by universities, governments, and business firms.

29. Mean - A measure of the central tendency of a set of data that is calculated by summing the values of the individual elements and dividing by the number of eldments.

EXHIBIT I (Continued)

30. Mean square - between groups - The between groups variance divided by the appropriate degrees of freedom in an analysis of variance model.

31. Mean square - within groups - The within groups variance divided by the appropriate degrees of freedom in an analysis of variance model.

32. NASA Center - A synonym for NASA Regional Dissemination Center.

33. Nonservice costs - The selling and administrative expenses of a NASA Center.

34. Normal production capacity - The service activity that will satisfy consumer demand over a period that is long enough to include seasonal, cyclical, and other trend factors.

35. Null hypothesis - A proposition that is tested statistically.

36. Operations overhead - The indirect service costs incurred during the production process.

37. Process costing - A costing technique in which the service costs are accumulated for a work function during a given time period but are not charged to specific products.

38. Profile search - A search of the current portion of the NASA file against an SDS interest profile.

39. Range - The difference between the high and low values of an array of data.

40. Responsibility accounting - The assignment of the controllable costs of a cost center to the employee responsible for the work activity.

41. Retrospective search - A search of a file of historical literature for information relevant to a well-defined problem.

42. RSS - Retrospective Search Service.

43. Sample - A subset of the universe of data that is selected for an inference concerning a population parameter.

44. SDS - Selective Dissemination Service.

45. SDS development costs - The service costs consumed, either directly or indirectly, for the development of an interest profile.

46. SDS maintenance costs - The service costs consumed, either directly or indirectly, to update the relevancy of the interest profile terms.

EXHIBIT I (Continued)

47. SDS operational costs - The service costs consumed for the profile searches, either directly or indirectly, during an SDS performance.

48. Service costs - The costs which are charged, either directly or indirectly, to the information services. The three types are direct labor, direct sundry expenses, and operations overhead.

49. Standard deviation - The square root of the average of the square of the deviations of the measurements about their mean.

50. Statistical cost control - The use of statistical sampling methods to control the direct service costs consumed during the information production process.

51. Subsidiary ledger - A detailed listing of the transactions summarized in a general ledger.

52. Type I error - The rejection of a true null hypothesis.

53. Type II error - The acceptance of a false null hypothesis.

54. Unit search cost - The total cost of an individual information search.

55. Universe - The entire population of data.

56. Variable cost - A cost which fluctuates in total in direct proportion to changes in service activity and is uniform per unit.

EXHIBIT II
RESEARCH QUESTIONNAIRE COVER LETTER

337-8884 May 19, 1967

Dear Sir:

I am currently engaged in a research project which is being sponsored by the Technology Utilization Division of NASA. The objective of the research is the design of a cost accounting system which is directly applicable to the operation of a technical information center such as those established in the NASA Regional Dissemination Program.

In order to be sure that I consider all aspects of the project, I would sincerely appreciate it if you would help me by filling out the enclosed questionnaire. I have attempted to design the questionnaire so that I can obtain specific information and yet leave enough flexibility that your individual opinions can also be generated.

The end result of the project will be an operating manual which I hope will be useful to all the regional centers. Any consideration that you can give my request will certainly be appreciated.

Sincerely,

JH jc

John G. Helmkamp

Enclosure

EXHIBIT II

RESEARCH QUESTIONNAIRE SURVEY RESULTS

FROM SEVEN NASA REGIONAL DISSEMINATION CENTERS

1. How is cost information presently obtained in the organization?

1	2	2	2	
Cost Accounting System	Statistical Cost System	Cost Estimation Studies	Rough Estimates	Other

Comments: ____________________

2. Is the responsibility for the cost information function delegated to any one specific person?

	3	2	2	
His Sole Responsibility	His Primary Responsibility	His Secondary Responsibility	No One in the Organization	Other

Comments: ____________________

3. At the present time, are there any specific forms being used for general control purposes, i.e. material requisiton, labor time reports, etc.?

6	1
Yes	No

Nature of the Reports: ____________________

4. What is the basis for the current fee schedule?

2	3	1		*1
Actual Costs	Statistical Costs	Rough Estimates	Fixed Fees Void of Costs	Other

Comments: *NONE

5. Do you presently bill clients as they use the services or on a fixed period basis?

	1	5	*1
Current	Semi-Annual	Annual	Other

Comments: SAME AS FOUR

EXHIBIT II (Continued)

6. Does the Center presently have a computer capability?

4	3
Yes	No

Comments: ______

7. Are the members of the staff:

1		6	
Full Time Engineers and Scientists	Part Time Engineers and Scientists	Both	Neither

Comments: ______

8. How many services are offered of a current awareness nature?

	5	1	1	
0	1	2	3	More Than 3

Comments: ______

9. How many services are offered of a retrospective search nature?

	5	2		
0	1	2	3	More Than 3

Comments: ______

10. Would the organization be willing to install a feasible cost accounting system if it were readily available?

7	
Yes	No

Comments: ______

11. Is there a need for accurate cost and operational information beyond your present capabilities?

6	*1
Yes	No

Comments: *NOT AT PRESENT STAGE OF DEVELOPMENT

EXHIBIT II (Continued)

12. How is the general accounting function, i.e. payroll, purchasing, etc., accomplished?

2	5
Internal to the Organization	External to the Organization

Comments: ______________________________

13. If an appropriate cost accounting system were operational in your organization, do you think that the following functions would be facilitated?

A. Planning, i.e. budgeting for future expenditures and manpower.

6	1
Yes	No

Comments: ______________________________

B. Controlling, i.e. adherence to the work schedule.

5	2
Yes	No

Comments: ______________________________

C. Performance evaluation, i.e. adherence to the work standards.

5	2
Yes	No

Comments: ______________________________

D. General decision-making, i.e. whether to purchase or lease equipment.

7	0
Yes	No

Comments: ______________________________

E. Directing the operation, i.e. determining the work schedule.

5	2
Yes	No

Comments: ______________________________

EXHIBIT II (Continued)

F. Pricing the services.

7 Yes   0 No

Comments: ____________________

14. Does the organization currently have a responsibility to report to external sources concerning cost performance?

2 Yes   5 No

Comments: ____________________

15. Does the organization currently utilize an internal reporting function concerning cost and operational information?

6 Yes   1 No

Comments: ____________________

16. If the answer to 15 is yes, what kind of reports are used, i.e. labor hours utilized, number of services performed, etc.?

Comments: SEE PAGE 264

17. Given the specific capabilities of your organization, what kind of cost information would you consider most useful?

A. SEE PAGE 264

B. ____________________

C. ____________________

D. ____________________

E. ____________________

Comments: ____________________

EXHIBIT II (Continued)

18. Given the specific capabilities of your organization, what kind of reports would you consider most useful?

A. SEE PAGE 264

B. ______

C. ______

D. ______

E. ______

Comments: ______

19. Given the specific capabilities of your organization, what managerial uses would you consider most important of cost and operational information if it were available?

A. SEE PAGE 264

B. ______

C. ______

D. ______

E. ______

Comments: ______

EXHIBIT II (Continued)

ANSWERS TO QUESTION 16.

1. LABOR HOURS
2. NUMBER OF SERVICES PERFORMED
3. COST STRUCTURE
4. COST BY FUNCTION
5. PERFORMANCE BY CLIENT

ANSWERS TO QUESTION 17.

1. COST BY SERVICE
2. RESOURCE ALLOCATION COSTS
3. COST/REVENUE COMPARISONS
4. SERVICE PRICE INFORMATION
5. BUDGETING
6. GENERAL MANAGEMENT INFORMATION
7. LABOR HOURS UTILIZED BY FUNCTION
8. COST PER FUNCTION
9. ENGINEERING AND CLERICAL WORK BY SERVICE
10. MATERIALS COST PER SERVICE
11. COMPUTER SEARCH COSTS
12. MARKETING COST METHODS
13. ADMINISTRATIVE COST ALLOCATION

ANSWERS TO QUESTION 18.

1. LABOR PERFORMANCE REPORTS
2. GENERAL COST REPORTS
3. NUMBER OF SEARCHES PERFORMED VERSUS MONTHLY COSTS
4. MATERIALS USAGE
5. OPERATING COSTS RELATED TO CLIENTELE ACTIVITY
6. MANPOWER REQUIREMENTS

ANSWERS TO QUESTION 19.

1. PLANNING NEW VENTURES
2. FEE SCHEDULE PREPARATION
3. ELIMINATE UNPROFITABLE SERVICE LINES
4. PRICING SERVICES TO SUBSCRIBERS
5. EVALUATING ALTERNATE METHODS AND EQUIPMENT
6. LEASE-BUY DECISIONS
7. EMPLOYEE EVALUATIONS
8. STUDIES OF ALTERNATIVE PRODUCTION SYSTEMS

EXHIBIT III

ARAC TEST PERIOD COST RESULTS

Sample Data - Unit Retrospective Search Costs

Sample Retrospective Search	July	August	September
1	96.02	69.04	64.31
2	85.57	98.26	88.34
3	68.46	64.31	64.59
4	73.21	97.15	42.27
5	84.26	82.33	104.15
6	78.11	94.27	118.54
7	87.63	128.06	57.90
8	78.53	101.25	54.73
9	76.63	95.68	103.13
10	75.64	71.52	58.88
11	82.98	76.23	117.23
12	102.37	44.32	83.85
13	81.94	71.47	107.37
14	93.27	101.22	125.10
15	105.48	92.41	94.09
16	52.86	59.75	114.17
17	169.37	88.78	83.09
18	73.76	65.98	78.94
19	75.65	94.17	109.73
20	61.64	126.54	66.97
Total	1,703.32	1,722.74	1,737.38
$\bar{X}$	85.17	86.13	86.87

Analysis of Variance Test

$$\sigma w^2 = \frac{\Sigma\Sigma\, x_{ij}^2 - \Sigma \frac{T_j^2}{n_j}}{N - k}$$

where
σw^2 = Mean square within columns
x_{ij} = Sample observation from the ith row and jth column
T_j = Total of jth column
n_j = Observations in the jth sample
N = Total sampled observations
k = Number of samples

$$= \frac{475{,}262 - 444{,}380}{57} = \frac{30882}{57} = \underline{\underline{542}}$$

EXHIBIT III (Continued)

$$\sigma B^2 = \frac{\frac{\Sigma T_j^2}{n_j} - \frac{T^2}{n}}{k - 1}$$

where σB^2 = mean square between columns
T = overall total observations

$$= \frac{444{,}380 - 444{,}276}{2} = \underline{\underline{52}}$$

$$F = \frac{\sigma B^2}{\sigma w^2} = \frac{52}{542} = \underline{\underline{.096}}$$

Critical region of "F" test is 3.17[1]

Thus, the null hypothesis that the monthly average retrospective searches are equal between months is accepted.

Sample Data - Unit Profile Search Costs

Sample Profile Search	July	August	September
1	$ 6.80	$ 9.67	$ 11.78
2	6.13	5.35	9.88
3	4.37	4.76	2.66
4	6.90	10.08	9.31
5	3.50	2.88	2.85
6	10.18	3.29	3.42
7	4.20	13.27	9.51
8	3.85	10.90	6.65
9	5.25	18.11	9.51
10	15.75	10.29	15.40
11	9.98	3.91	8.75
12	5.25	4.73	6.27
13	13.13	3.50	4.37
14	2.80	8.23	7.03
15	8.93	2.26	10.26
16	15.93	6.79	8.74
17	5.42	2.88	1.90
18	16.43	7.20	8.55
19	3.50	7.41	2.28
20	2.10	3.91	6.46
21	17.15	10.29	2.09
22	3.85	11.31	7.03
23	6.30	8.64	3.04
24	2.80	7.41	6.84
25	6.12	3.50	17.30
Total	$186.62	$180.54	$181.88
$\bar{X}$	$ 7.46	$ 7.22	$ 7.28

---

[1] Paul G. Hoel, Introduction to Mathematical Statistics (3rd ed.; New York: John Wiley and Sons, Inc., 1962), p. 406.

EXHIBIT III (Continued)

Analysis of Variance Test

$$\sigma_w^2 = \frac{\Sigma\Sigma x_{ij}^2 - \frac{\Sigma T_j^2}{n_j}}{N - k}$$

(Terms are the same as retrospective search case.)

$$= \frac{5040.25 - 4020.08}{72} = \frac{1020.37}{72} = 14.17$$

$$\sigma_B^2 = \frac{\frac{\Sigma T_j^2}{n_j} - \frac{T^2}{n}}{k - 1}$$

(Terms are the same as the retrospective search case.)

$$= \frac{4020.08 - 4019.26}{2} = \frac{.82}{2} = .41$$

$$F = \frac{\sigma_B^2}{\sigma_w^2} = \frac{.41}{14.17} = .029$$

Critical region of "F" test is 3.13[2]

Thus, the null hypothesis that the monthly average profile searches are equal between months is accepted.

---

[2] *Ibid.*

EXHIBIT IV

EMPLOYEE DAILY TIME TICKET

NAME ______________________ DATE ______________

COST CENTER ________________ CHECKED BY __________

A.M.	WORK ACTIVITY	P.M.	WORK ACTIVITY
600		1200	
15		15	
30		30	
45		45	
700		100	
15		15	
30		30	
45		45	
800		200	
15		15	
30		30	
45		45	
900		300	
15		15	
30		30	
45		45	
1000		400	
15		15	
30		30	
45		45	
1100		500	
15		15	
30		30	
.45		45	
1200		600	

COST CODES	EXPLANATION
RSG	RSS General Time
RSM	RSS Maintenance Time
RS (DIGITS)	SPECIFIC Retrospective Search
SDD (DIGITS)	SDS Development for Specific Profile
SDM	SDS Maintenance Time
SD (DIGITS)	Specific SDS Performance
SS	Special Projects
OS	Other Services
OP	General Admin. Time

EXHIBIT V

WORK ORDER

JOB NUMBER ______________________

ORIGINATOR ______________________ DATE ______________________

SERVICE CODE ______________________ DATE REQUESTED ______________________

INSTRUCTION CODES:

- A - Abstracts
- D - Full Documents
- R - Reproduce
- P - Photocopy
- F - Microfiche
- C - Collate
- B - Bind
- T - Trim
- O - Other

REQUEST NUMBER	COPIES	CODE	REQUEST NUMBER	COPIES	CODE

SPECIAL INSTRUCTIONS ____

____

WORK PERFORMED (QUANTITY)

MICRO FICHE	PHOTO COPY	COPY	MATS	PAPER	OTHER

EXHIBIT VI

TELEPHONE RECORD

CALLER	SERVICE	CLIENT	LOCATION	DATE

EXHIBIT VII

TRAVEL VOUCHER

TRAVEL VOUCHER NUMBER ______________________ DATE LEFT ______________

EMPLOYEE ________________________________ DATE RETURNED ___________

REASON FOR TRIP ____

____

CLIENTELE VISITED | SERVICES DISCUSSED

1. ____
2. ____
3. ____
4. ____
5. ____

LIST OF EXPENSES	AMOUNT	DISTRIBUTION

EXHIBIT VIII

OPERATIONS OVERHEAD BUDGETING

Selection of a Predetermined Operations Overhead Rate

1. Select a feasible work activity basis for overhead allocation that will relate the indirect costs to the information services, as realistically as possible, in proportion to their benefit from the overhead. Possible bases are direct labor cost, direct labor hours, computer time, or service units.

2. Determine reasonable capacity levels, measured by the selected work activity basis, for an annual operating period of the center.

3. Determine all variable operations overhead items for the different activity levels selected in 2.

4. Designate the constant fixed operations overhead costs for the operating period.

5. Estimate the consumer demand expected for the information services during the period.

6. On the basis of 5, select the normal operating capacity of the flexible budget which relates the work activity basis to the forecast consumer demand.

7. Divide the total operations overhead at normal capacity by the related work activity measure for the calculation of the appropriate application rate.

8. Keypunch the rate selected in 7 onto the section overhead rate card shown in Appendix I for computerized processing. The program is designed presently to apply the overhead on the basis of direct labor costs so it must be revised if another activity basis is chosen.

EXHIBIT VIII (Continued)

TECHNICAL INFORMATION CENTER
OPERATIONS OVERHEAD FLEXIBLE BUDGET
YEAR ENDING DECEMBER 31, 19xx

				Normal Capacity		
Direct Labor Costs	$50,000	$60,000	$70,000	$80,000	$90,000	$100,000
Variable Operations Overhead						
Engineer Reading Time	2,500	3,000	3,500	4,000	4,500	5,000
Indirect Engineer Time	7,500	9,000	10,500	12,000	13,500	15,000
Idle Time	4,000	4,800	5,600	6,400	7,200	8,000
Staff Meetings	1,500	1,800	2,100	2,400	2,700	3,000
Operating Supplies	5,000	6,000	7,000	8,000	9,000	10,000
Maintenance	1,000	1,200	1,400	1,600	1,800	2,000
Power	2,000	2,400	2,800	3,200	3,600	4,000
Postage	1,000	1,200	1,400	1,600	1,800	2,000
Miscellaneous	1,500	1,800	2,100	2,400	2,700	3,000
Total Variable	$26,000	$31,200	$36,400	$41,600	$46,800	$52,000
Fixed Operations Overhead						
Supervision	18,000	18,000	18,000	18,000	18,000	18,000
Rent	6,000	6,000	6,000	6,000	6,000	6,000
Insurance	2,000	2,000	2,000	2,000	2,000	2,000
Depreciation	3,600	3,600	3,600	3,600	3,600	3,600
Equipment Rental	2,400	2,400	2,400	2,400	2,400	2,400
Telephone	1,200	1,200	1,200	1,200	1,200	1,200
Miscellaneous	2,000	2,000	2,000	2,000	2,000	2,000
Total Fixed Operations Overhead	35,200	35,200	35,200	35,200	35,200	35,200
Total Operations Overhead	$61,200	$66,400	$71,600	$76,800	$82,000	$88,200
Predetermined Overhead Rate	$1.2240	$1.1167	$1.0229	$.9600	$.9111	$.8820

EXHIBIT IX

TECHNICAL INFORMATION CENTER

CHART OF ACCOUNTS

Assets

1000	Cash
1050	Contracts Receivable
1100	Accounts Receivable
1150	Operating Supplies
1200	Prepaid Expenses
1250	Office Equipment
1300	Operations Equipment
1350	Microfiche
1400	Computer Tapes
1450	Buildings
1500	Land
1550	SDS Development
1570	Other Assets
1600	Allowance for Depreciation - Office Equipment
1650	Allowance for Depreciation - Operations Equipment
1700	Allowance for Depreciation - Microfiche
1750	Allowance for Depreciation - Computer Tapes
1800	Allowance for Depreciation - Buildings

Liabilities

2000	Vouchers Payable
2050	Accrued Wages Payable
2100	Accrued Copying Expenses
2150	Accrued Computer Expenses
2200	Other Accrued Expenses
2250	Deferred Income

Capital

3000	Center Fund Balance

Revenues

4000	Revenue Control
4050	Clientele Payments
4100	Other Revenue

Cost of Services

5000	Cost of Services Completed

Revenue & Expense Summary

6000	Revenue and Expense Summary

EXHIBIT IX (Continued)

Operations Expenses

7000	Operations Control
7010	Engineer Labor
7020	Operating Supplies
7030	Documents
7040	Telephone and Telegraph - Operations
7050	Company Travel - Nonservice
7060	Miscellaneous
7110	Clerical Labor
7120	Operating Supplies
7160	Miscellaneous
7210	Reproduction Labor
7220	Operating Supplies
7230	Equipment Rental
7240	Photocopying and Microfiche Production
7250	Printing and Duplicating
7260	Postage - Operations
7270	Maintenance Agreements
7280	Miscellaneous
7310	Computer Labor
7320	Computer Time
7330	Miscellaneous
7510	Fringe Benefits - Operations
7520	General Administration Charged to Operations
7530	Depreciation - Operating Equipment
7540	Depreciation - Computer Equipment
7560	Miscellaneous

General Administrative Expenses

8000	General Administrative Control
8050	General Administrative Labor
8100	Fringe Benefits - Administration
8150	Retirement - Administration
8200	Supplies - Administration
8250	Telephone and Telegraph - Administration
8300	Equipment Rental - Administration
8350	Printing and Duplication - Administration
8400	Repairs - Administration
8450	Depreciation - Administrative Office Equipment
8500	Miscellaneous Travel
8550	Rent
8600	Maintenance Agreements
8650	Magazine Subscriptions
8700	Postage
8750	Miscellaneous

EXHIBIT IX (Continued)

Selling Expenses

9000	Selling Expenses Control
9100	Advertising
9200	Promotion
9300	Meetings
9400	Promotion Travel
9500	Miscellaneous

Service Accounts

0100	RSS in Process Control
0200	Finished RSS Control
0300	SDS in Process Control
0400	Finished SDS Control
0500	Other Services Control

EXHIBIT X.

TECHNICAL INFORMATION CENTER
BALANCE SHEET
JANUARY 31, 19xx

ASSETS

Current Assets:		
Cash		$ 16,850
Contracts Receivable		54,930
Accounts Receivable		15,620
Operating Supplies		1,212
Services in Process		6,846
Prepaid Expenses		2,482
Total Current Assets		$ 97,940
Fixed Assets:		
Office Equipment	$ 8,404	
Allowance for Depreciation	1,264	7,140
Operations Equipment	15,640	
Allowance for Depreciation	3,220	12,420
Computer Tapes	843	
Allowance for Depreciation	112	731
Microfiche	3,640	
Allowance for Depreciation	820	2,820
Buildings	15,634	
Allowance for Depreciation	3,843	11,791
Land		2,000
SDS Development		6,890
Other Assets		1,210
Total Fixed Assets		45,002
Total Assets		$142,942

LIABILITIES & FUND BALANCE

Current Liabilities:	
Vouchers Payable	$ 16,840
Accrued Wages	5,210
Accrued Copying Expenses	685
Other Accrued Expenses	232
Deferred Income	52,340
Total Current Liabilities	$ 75,307
Center Fund Balance:	
Center Fund Balance	67,635
Total Liabilities and Fund Balance	$142,942

EXHIBIT X (Continued)

TECHNICAL INFORMATION CENTER
INCOME STATEMENT
MONTH ENDING JANUARY 31, 19xx

Revenue		
Retrospective Search Service Revenue	$4,878	
Selective Dissemination Service Revenue	7,318	
Special Projects Revenue	2,424	
Miscellaneous Revenue	516	
Total Revenue		$15,136
Cost of Services Performed		
Retrospective Search Service	$3,902	
Selective Dissemination Service	5,854	
Special Projects	1,939	
Miscellaneous Services	413	
Cost of Services Performed		$12,108
Gross Margin		$ 3,028
Selling and Administrative Expenses		
Selling Expenses	$ 757	
Administrative Expenses	2,215	
Total Selling and Administrative Expenses		$ 2,962
Excess of Revenues over Operating Costs		$ 66

EXHIBIT XI

TECHNICAL INFORMATION CENTER
ENGINEER SECTION
COST CENTER PERFORMANCE REPORT
MONTH ENDING JANUARY 31, 19xx

COST ITEM	MONTH OF JANUARY BUDGET	ACTUAL	VARIANCE	YEAR TO DATE BUDGET	ACTUAL	VARIANCE
Direct Labor	$4400	$4512	$(112)	$4400	$4512	$(112)
Idle Time	550	830	(280)	550	830	(280)
Meetings	110	102	8	110	102	8
Engineer Reading	165	195	(30)	165	195	(30)
Supplies	210	215	(5)	210	215	(5)
Computer Time	1250	1630	(380)	1250	1630	(380)
Telephone	640	610	30	640	610	30
Travel	845	955	(110)	845	955	(110)
Miscellaneous	150	140	10	150	140	10
Total Expenses	$8320	$9189	$(869)	$8320	$9189	$(869)

( ) denotes an unfavorable variance.

EXHIBIT XII

TECHNICAL INFORMATION CENTER
SERVICE COST REPORT
MONTH ENDING JANUARY 31, 19xx

SERVICE RSS NUMBER	DIRECT LABOR	DIRECT SUNDRY EXPENSES	OPERATIONS OVERHEAD	TOTAL SERVICE COSTS
1450	$ 44.15	$ 21.30	$ 39.73	$105.18
1451	46.20	19.20	41.50	106.90
1452	32.10	17.10	28.89	78.09
1453	36.15	17.05	32.53	85.73
1454	28.10	16.15	25.29	69.54
1455	36.45	18.10	32.80	87.35
1456	41.10	18.05	36.99	96.14
1457	43.25	16.10	38.92	98.27
1458	44.50	18.10	40.05	102.65
1459	31.15	17.15	28.03	76.33
TOTAL RSS	$383.15	$178.30	$344.73	$906.18
SDS NUMBER				
15	$ 796.81	$ 481.55	$ 718.03	$1996.39
16	1025.25	465.10	922.72	2413.07
17	885.15	475.15	796.63	2156.93
TOTAL SDS	$2707.21	$1421.80	$2437.38	$6566.39
SPECIAL PROJECT				
21	$ 318.30	$ 96.15	$ 286.47	$ 700.92
22	110.20	56.30	99.18	265.68
23	58.60	13.20	52.74	124.54
TOTAL SPECIAL PROJECT	$ 487.10	$ 165.65	$ 438.39	$1091.14

EXHIBIT XIII
TECHNICAL INFORMATION CENTER
REVENUE - COST REPORT
YEAR ENDING DECEMBER 31, 19xx

CLIENTELE SERVICE

CLIENT A	REVENUE	ACTUAL COST	DIFFERENCE
RSS 1450	$ 85.00	$ 95.10	($10.10)
RSS 1461	85.00	105.20	(20.20)
RSS 1492	85.00	62.90	22.10
RSS 1525	85.00	60.80	24.20
RSS 1585	85.00	72.00	13.00
RSS 1610	85.00	98.00	(13.00)
Total RSS	510.00	494.00	16.00
SDS Profile 51	295.00	310.90	(15.90)
SDS Profile 52	195.00	185.60	9.40
SDS Profile 53	395.00	386.40	8.60
SDS Profile 54	295.00	335.20	(40.20)
Total SDS	1180.00	1218.10	(38.10)
Total Client A	1690.00	1712.10	(22.10)

CLIENT B			
RSS 1522	85.00	98.20	(13.20)
RSS 1605	85.00	110.30	(25.30)
RSS 1626	85.00	69.15	15.85
RSS 1681	85.00	165.10	(80.10)
RSS 1699	85.00	62.15	22.85
Total RSS	425.00	504.90	(79.90)
SDS Profile 30	495.00	512.16	(17.16)
SDS Profile 31	195.00	164.80	30.20
SDS Profile 32	495.00	415.50	79.50
SDS Profile 33	295.00	310.20	(15.20)
SDS Profile 34	295.00	300.40	(5.40)
Total SDS	1775.00	1703.06	71.94
Total Client B	$2200.00	$2207.96	($ 7.96)

( ) denotes unfavorable variance.

*EXHIBIT XIV

TECHNICAL INFORMATION CENTER
OVERHEAD ANALYSIS REPORT
YEAR ENDING DECEMBER 31, 19xx

Actual Direct Labor Costs Recorded - - - - - - - - $78,500

COST ITEM	Normal Capacity Budget-$80,000	Adjusted Budget at $78,500 Capacity	Actual Costs	Budget Variance
Variable Opns. Ovhd.				
Engineer Reading Time	$ 4,000	$ 3,925	$ 4,030	($ 105)
Indirect Engineer Time	12,000	11,775	12,562	(787)
Idle Time	6,400	6,280	6,024	256
Staff Meetings	2,400	2,355	2,516	(161)
Operating Supplies	8,000	7,850	7,762	88
Maintenance	1,600	1,570	1,940	(370)
Power	3,200	3,140	3,210	(70)
Postage	1,600	1,570	1,380	190
Miscellaneous	2,400	2,355	2,310	45
Total Variable	41,600	40,820	41,734	(914)
Fixed Opns. Ovhd.				
Supervision	18,000	18,000	18,230	(230)
Rent	6,000	6,000	6,110	(110)
Insurance	2,000	2,000	1,890	110
Depreciation	3,600	3,600	3,714	(114)
Equipment Rental	2,400	2,400	2,560	(160)
Telephone	1,200	1,200	1,155	45
Miscellaneous	2,000	2,000	2,612	(612)
Total Fixed	35,200	35,200	36,271	(1,071)
Total Operation Overhead	$76,800	(1)$76,020	(4)$78,005	
Budget Variance (1 less 4)				($1,985)
Operations Overhead applied at $.96 per direct labor cost or $78,500 x .96 -		(2)$75,360	(3)$75,360	
Volume Variance (1 less 2)		($660)		
Total Oper. Ovhd. Variance (4 less 3)			($2,645)	

( ) denotes unfavorable variance.

* This report is based on the budget data of Exhibit VIII.

283

EXHIBIT XV

JOB ORDER COST SHEET
RETROSPECTIVE SEARCH SERVICE

RSS NUMBER ______________________ DATE STARTED ______________

CLIENT ______________________ DATE COMPLETED ______________

ENGINEER ______________________ SELLING PRICE ______________

Labor				Direct Sundry Expenses								Opn. Ovhd.		Total
Direct Labor		Gen. Labor		Computer		Telephone		Reproduction		Other				
*Ref.	*Am.	*Ref.	*Am.	*Ref.	*Am.	*Ref.	*Am.	*Ref.	*Am.	*Ref.	*Am.	*Ref.	*Am.	

* Ref. = Reference for source of the entry.
* Am. = Amount of the entry.

EXHIBIT XVI

STATISTICAL COST SYSTEM SAMPLE COST SHEET

SEARCH NUMBER ____________________ DATE STARTED ____________________

CLIENT ____________________ DATE FINISHED ____________________

ENGINEER ____________________ SELLING PRICE ____________________

Direct Labor		Computer		Reproduction Charges		Telephone		Travel		Other Expenses		Total Costs Recorded in $
Code / Date	Quant.	Code / Date	Quant.	Code / Date	Quant.	Code / Date	Quant.	Code / Date	Quant.	Code / Date	Quant.	

Code = The code number of the employee recording the cost item.
Date = The date of the cost consumption.
Quant = The quantity of items consumed (i.e. - 3 direct labor hours).

BIBLIOGRAPHY

BIBLIOGRAPHY

Books

Accounting and Reporting Problems of the Accounting Profession. 2nd ed.; Chicago, Ill.: Arthur Andersen & Co., 1962.

Accounting Research and Terminology Bulletins. Final ed.; New York: American Institute of Certified Public Accountants, 1961.

Anthony, Robert N. Management Accounting. 3rd ed.; Homewood, Ill.: Richard D. Irwin, Inc., 1964.

Baldwin, Emma E. and Marcus, W. E. Library Costs and Budgets; a Study of Cost Accounting in Public Libraries. New York: Bowker, 1941.

Berul, Lawrence. Information Storage and Retrieval - A State of the Art Report. Philadelphia, Penn.: Auerbach Corporation, 1964.

Bowman, Edward H. and Fetter, Robert B. Analysis for Production Management. Rev. ed.; Homewood, Ill.: Richard D. Irwin, Inc., 1961.

Chapin, Ned. An Introduction to Automatic Computers. 2nd ed.; Princeton, N. J.: D. Van Nostrand Co., 1963.

Costs of Public Library Service in 1959; a Supplement to Public Library Service, a Guide to Evaluation with Minimum Standards. Chicago, Ill.: American Library Association, 1960.

Dickey, Robert I. (ed.) Accountants' Cost Handbook. 2nd ed.; New York: The Ronald Press Company, 1960.

Duncan, Acheson J. Quality Control and Industrial Statistics. 3rd ed.; Homewood, Ill.: Richard D. Irwin, Inc., 1965.

Elliott, C. Orville and Wasley, Robert S. Business Information Processing Systems. Homewood, Ill.: Richard D. Irwin, Inc., 1965.

Fabrycky, Walter J. and Torgersen, Paul E. Operations Economy: Industrial Applications of Operations Research. Englewood Cliffs, N. J.: Prentice-Hall, Inc., 1966.

Fetter, Robert B. The Quality Control System. Homewood, Ill.: Richard D. Irwin, Inc., 1967.

FORTRAN, Programmed Instruction Course. White Plains, New York: International Business Machines Corporation, 1963.

Gillespie, Cecil. Cost Accounting and Control. Englewood Cliffs, N. J.: Prentice-Hall, Inc., 1957.

Grant, Eugene. Statistical Quality Control. 3rd ed.; New York: McGraw-Hill Book Company, Inc., 1964.

Guenther, William C. Concepts of Statistical Inference. New York: McGraw-Hill Book Company, 1965.

Hamberg, Daniel. Essays on the Economics of Research and Development. New York: Random House, 1966.

Hansen, Morris H., Hurwitz, William N., and Madow, William G. Sample Survey Methods and Theory. New York: John Wiley & Sons, Inc., 1953.

Hoel, Paul G. Introduction to Mathematical Statistics. 3rd ed.; New York: John Wiley & Sons, Inc., 1962.

Horngren, Charles T. Cost Accounting - A Managerial Emphasis. 2nd ed.; Englewood Cliffs, N. J.: Prentice-Hall, Inc., 1967.

Kennedy, Ralph Dale and McMullen, Stewart Yarwood. Financial Statements - Form, Analysis, and Interpretation. 4th ed.; Homewood, Ill.: Richard D. Irwin, Inc., 1962.

Kent, Allen. Specialized Information Centers. Washington, D. C.: Spartan Books, 1965.

Leftwich, Richard H. The Price System and Resource Allocation. Rev. ed.; New York: Holt, Rinehart, and Winston, 1963.

Lesher, Richard L. and Howick, George J. Background, Guidelines, and Recommendations for Use in Assessing Effective Means of Channeling New Technologies in Promising Directions. Report prepared for the National Commission on Technology, Automation, and Economic Progress. Washington, D. C.: National Aeronautics and Space Administration, 1965.

Martin, E. Wainright. Electronic Data Processing - An Introduction. Rev. ed.; Homewood, Ill.: Richard D. Irwin, Inc., 1965.

Matz, Adolph; Curry, Othel J.; and Frank, George W. Cost Accounting. 4th ed.; Cincinnati, Ohio: South-Western Publishing Company, 1967.

Mood, Alexander M. and Graybill, Franklin A. Introduction to the Theory of Statistics. 2nd ed.; New York: McGraw-Hill Book Company, 1963.

Moore, Carl L. and Jaedicke, Robert K. Managerial Accounting. 2nd ed.; Cincinnati, Ohio: South-Western Publishing Company, 1967.

Nelson, Oscar S. and Woods, Richard S. Accounting Systems and Data Processing. Cincinnati, Ohio: South-Western Publishing Company, 1961.

Neuner, John J. W. and Frumer, Samuel. Cost Accounting - Principles and Practice. 7th ed.; Homewood, Ill.: Richard D. Irwin, Inc., 1967.

Performance Budgeting for Libraries. Chicago, Ill.: Municipal Finance Officers Association, 1954.

Perry, James W. and Kent, Allen. Tools for Machine Literature Searching. New York: Interscience Publishers, Inc., 1958.

Preparation of Search Profiles. Columbus, Ohio: The American Chemical Society, 1967.

Roberts, Harry V. Statistical Inference and Decision. Chicago, Ill.: University of Chicago, 1966.

Schlaifer, Robert. Probability and Statistics for Business Decisions. New York: McGraw-Hill Book Company, 1959.

Shillinglaw, Gordon. Cost Accounting - Analysis and Control. Rev. ed.; Homewood, Ill.: Richard D. Irwin, Inc., 1967.

Timms, Howard L. The Production Function in Business. Rev. ed.; Homewood, Ill.: Richard D. Irwin, Inc., 1966.

Trueblood, Robert M. and Cyert, Richard M. Sampling Techniques in Accounting. Englewood Cliffs, N. J.: Prentice-Hall, Inc., 1957.

Vance, Lawrence. Theory and Techniques of Cost Accounting. Rev. ed.; New York: Henry Holt and Company, 1958.

_______, and Neter, J. Statistical Sampling for Auditors and Accountants. New York: John Wiley & Sons, Inc., 1956.

Villers, Raymond. Research and Development: Planning and Control. New York: Financial Executives Research Foundation, Inc., 1964.

Articles and Periodicals

Bourne, Charles P. and Ford, Donald F. "Cost Analysis and Simulation Procedures for the Evaluation of Large Information Systems," American Documentation, XV (April, 1964), pp. 142-149.

Brownlow, J. L. "Cost Analysis for Libraries," District of Columbia Libraries, XXXI (October, 1960), pp. 54-60.

Brutcher, Constance; Gessford, Glen; and Rixford, Emmet. "Cost Accounting for the Library," Library Resources and Technical Services, VIII (Fall, 1964), pp. 413-431.

Bryan, W. W. and Carroll, B. W. "Public Library Budgeting and Accounting," Illinois Libraries, XXXXII (June, 1960), pp. 384-91.

Carlisle, Howard M. "Cost Accounting for Advanced Technology Programs," The Accounting Review, XLI (January, 1966), pp. 115-120.

Chinoy, Ely. "The Tradition of Opportunity and the Aspiration of Automobile Workers," The American Journal of Sociology, LVIII (March, 1952), pp. 453-459.

Cummings, Larry. "Organizational Climates for Creativity," Journal of the Academy of Management, VIII (September, 1965), pp. 220-227.

Danilov, Victor J. "1967 I-R Forecast: $24 Billion for Research," Industrial Research, (January, 1967), pp. 31-53.

Dennis, Bernard K. "Financing a Technical Information Center," Information Retrieval Management, ed. Lowell H. Hattery and Edward M. McCormick (Detroit, Mich.: American Data Processing, Inc., 1962), pp. 61-75.

Dougherty, Richard M. "The Scope and Operating Efficiency of Information Centers," College and Research Libraries, XXIV (January, 1964), pp. 7-11.

Friedlander, Frank and Walton, Eugene. "Positive and Negative Motivations Toward Work," Administrative Science Quarterly, IX (September, 1964), pp. 194-207.

Gauss, D. B. "Reporting Departmental Costs of Research Projects," N.A.A. Bulletin, XL (September, 1958), pp. 32-34.

Hanson, C. W. "Costing Information Services," Aslib Proceedings, III (May, 1951), pp. 85-88.

Harbrecht, Robert F. "Designing a System for Control of Research Cost," N.A.A. Bulletin, XLV (June, 1964), pp. 3-8.

Hiller, James. "Management's Evaluation of Information Services," Information Retrieval Management, ed. Lowell H. Hattery and Edward M. McCormick (Detroit, Mich.: American Data Processing, Inc., 1962), pp. 54-60.

Kean, Milton. "Some Suggestions for Preparing a Chart and Manual of Accounts," N.A.C.A. Bulletin, XXXVII (April, 1956), pp. 1002-1009.

Langenbeck, Earl H. "A Plan to Reduce Costs of Technical Library Operations in the Department of Defense," American Documentation, XIII (July, 1962), pp. 295-300.

LaPorte, Todd R. "Conditions of Strain and Accomodation in Industrial Research Organizations," Administrative Science Quarterly, X (June, 1965), pp. 21-38.

Leake, Chauncey D. "What Must Give in the Documentation Crisis?," Information Retrieval Management, ed. Lowell H. Hattery and Edward M. McCormick (Detroit, Mich.: American Data Processing, Inc., 1962), pp. 15-21.

Marron, Harvey and Snyderman, Martin. "Cost Distribution and Analysis in Computer Storage and Retrieval," American Documentation, XVII (April, 1966), pp. 89-94.

McCormick, Edward M. "The Management Process and Science Information Systems," Information Retrieval Management, ed. Lowell H. Hattery and Edward M. McCormick (Detroit, Mich.: American Data Processing, Inc., 1962), pp. 131-135.

McFadden, James A. "Cost Accounting for a Research Laboratory," N.A.C.A. Bulletin, XXXII (March, 1951), pp. 822-838.

_______. "Industrial Research Must Be Planned and Controlled," The Controller, XXIX (November, 1961), pp. 527-532.

_______. "New Concepts of Information for Management Decisions - Research and Development," N.A.A. Bulletin, XL (August, 1959), pp. 19-26.

"Memorandum Prepared by the Office of the Chief Accountant, Securities and Exchange Commission," Inventory of Generally Accepted Accounting Principles for Business Enterprises, ed. Paul Grady (New York: American Institute of Certified Public Accountants, Inc., 1965), pp. 385-397.

Mueller, Max W. "Time, Cost, and Value Factors in Information Retrieval," General Information Manual: Information Retrieval Systems Conference September 21-23, 1959, Poughkeepsie (White Plains, New York: International Business Machines, 1960), pp. 12-24.

National Association of Accountants (formerly National Association of Cost Accountants), "The Analysis of Manufacturing Cost Variances," N.A.C.A. Bulletin, XXXIII (August, 1952), pp. 1548-1555.

Newman, Simon M. "Economic Justification - Factors Establishing Systems Costs," Information Retrieval Management, ed. Lowell H. Hattery and Edward D. McCormick (Detroit, Mich.: American Data Processing, Inc., 1962), pp. 117-119.

Nitecki, Andre. "Cost Accounting Forms," Michigan Librarian, XXIX (December, 1963), pp. 19-21.

Overmeyer, LaVahn. "An Analysis of Output Costs and Procedures for an Operational Searching Service," American Documentation, XIV (April, 1963), pp. 123-142.

______. "The Dollars and Cents of Basic Operations in Information Retrieval," Information Retrieval in Action (Cleveland, Ohio: The Press of Western Reserve University, 1963), pp. 199-211.

Pearson, Gordon F. "Allocating the Costs of a Data Processing Department," N.A.A. Bulletin, XXXIX (May, 1958), pp. 61-69.

Peters, Alex. "Cost Accounting/Allocation," Technical Information Center Administration, ed. Arthur W. Elias (Washington, D. C.: Spartan Books, Inc., 1964), pp. 104-120.

Pflieger, John H. "Control Accounting for Sponsored Research Contracts," N.A.A. Bulletin, XXXIX (March, 1958), pp. 77-91.

Quinn, James B. "Study of the Usefulness of Research and Development Budgets," N.A.A. Bulletin, XL (September, 1958), pp. 79-90.

Schmieg, Harry J. "Control of Overhead with a Variable Budget in a Research Operation," N.A.A. Bulletin, XL (August, 1959), pp. 45-56.

Sherrod, John. "Functions of a Technical Information Center," Information Retrieval Management, ed. Lowell H. Hattery and Edward M. McCormick (Detroit, Mich.: American Data Processing, Inc., 1962), pp. 34-36.

Taylor, L. "Cost Research on a Library Service," Aslib Proceedings, XIII (September, 1961), pp. 238-248.

Vance, Lawrence L. "Capsule Cases in Statistical Cost Control," N.A.C.A. Bulletin, XXXVI (January, 1955), pp. 682-688.

Other

U. S. Statutes at Large. Vol. LXXII.

Weimer, Arthur. The Programs of the Aerospace Research Applications Center, Excerpts from a speech presented at the CIC Conference on "The Flow of Innovation and the Management of Research" at Wingspread, Wisconsin, October 26, 1965.

VITA

NAME:	John Gerhardt Helmkamp
BORN:	Lafayette, Indiana; July 19, 1938
DEGREES:	B.S. Purdue University, 1960
	M.B.A. Indiana University, 1965
	D.B.A. Indiana University, 1968
TEACHING EXPERIENCE:	Teaching Associate, Indiana University, 1964-1968
MEMBERSHIPS:	Beta Gamma Sigma Beta Alpha Psi