THE GRID CHARTING TECHNIQUE FOR MANAGEMENT
INFORMATION SYSTEMS

DISSERTATION

Presented in Partial Fulfillment of the Requirements for
Degree Doctor of Philosophy in the Graduate
School of The Ohio State University

By

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* * * * * *

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PREFACE

Although computers have revolutionized management information systems, little progress has been made in the analysis and design techniques employed in systems effort; systems knowledge has been acquired by trial and error. The field of management information systems lacks theory and its techniques are early 20th century.

My incentive for this study grew out of a recognition that management information systems and business organization are actually related through the inseparable management functions of communication and decision-making.

Throughout this study I have received able support from many individuals. Their support has been a vital force which explains any contribution made by this dissertation.

I wish to thank the students who participated in this study. Special thanks are due Colonels Howard Seim, Thomas Peddy, Charles A. Stone, and Edward McCloy, USAF, whose assistance made this study a reality.

I would like to acknowledge my appreciation to Dr. Ralph C. Davis, Dr. Robert B. Miner, and Dr. William E. Schlender who served as my reading and examining committee and provided valuable assistance in this study.

Dr. Charles B. Hicks, my adviser during my studies at The Ohio State University, and also my counsel during the writing of this
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grope and discover for myself what I am sure he already anticipated.
His optimism helped me over many hurdles.

Miss Joyce Sigler and Miss Barbara Almanrode are to be commended
for their typing contributions.

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and assistance. In addition to managing four lively children and
a household, her warm smile and constant encouragement provided the
support so often needed in educational studies.

Finally, my heartfelt thanks to Roberta, Nancy Lynn, and the
twins, Gordon, Jr. and Mary Beth, for enduring my long absences from
home. I hope this dissertation, and what it represents, is a partial
recompense for the many trips we had to forgo.
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CHAPTER I

INTRODUCTION

It was the purpose of this study to analyze the use, applications, and limitations of the grid charting technique as a model for the analysis and design of management information systems. The grid charting technique is an analytical technique which may be used to display the data processes, information requirements, responsibilities, and authorities operating in a management information system. The grid charting technique has not been used extensively in industry but is being used by the Air Force Logistics Command as a result of the encouragement of management\(^1\) and its explanation in a series of 24 three-week seminars in the Fundamentals of Data Systems Analysis conducted from May, 1961, to October, 1963.

Instrumental in the conduct of this study was the establishment of the Directorate of Data Systems\(^2\) with responsibility for the development and implementation of (1) Air Force standard materiel data systems and (2) data systems for the Air Force Logistics Command management.

One of the first and most important requirements recognized in the decision to centralize the command data system design and

\(^1\) Specifically Major General F. C. Gideon and Colonel Edward McCloy.

development effort was the need for arriving at common rules and understanding for doing the highly technical job assigned to the new directorate. A comprehensive training program was developed to assure that a common approach was followed by the specialists and management personnel who came into the organization from many different environments. This program included on-the-job training, specialized training for programmers, a short directorate orientation course for all personnel, and the establishment of a three-week course on the Fundamentals of Data Systems Analysis in the School of Systems and Logistics. This course offered the opportunity to present concepts to be subjected to later analysis.

The grid charting technique employs two tabular formats called grid charts and decision logic tables. The grid charts are used to display the flows of data through the data processes to the various business functions. Decision logic tables are used to display information requirements by relating decision conditions to management actions. The supply or flow of information can be equated to actual management demands for information by comparing the flow of information portrayed in grid charts to the information needs of management portrayed in decision logic tables. The grid charting technique discussed here has evolved from the Lieberman Mathematical Model, the Tabular Analysis of Burton Grad and the Management Concepts of Ralph C. Davis.

One cannot analyze a technique without also analyzing its relation to a sound management philosophy and the theoretical base
supporting it. "Effective, economical solutions of business problems require the practical application of a sound management philosophy." \(^3\)

The specific objectives of this study, therefore, were--

1. To develop and teach a theory of management information systems and the grid charting technique.
2. To measure the degree of usefulness of the theory of management information systems and the grid charting technique.
3. To identify the advantages and disadvantages of the grid charting technique.
4. To identify modifications made to the grid charting technique.
5. To identify factors limiting the use of the grid charting technique.

This study describes (1) a theory of management information systems developed as the theoretical base supporting the grid charting technique and (2) the grid charting technique by which a systems analyst can model large scale management information systems. The primary research of this study concentrated on the evaluation of the grid charting technique.

**Importance of the Problem**

It is believed that this study has value for the following reasons--

1. The need for analytical techniques in systems
2. The large number of employees involved in or with information systems

---

3. The increased use of computers in information systems

4. The evergrowing need for data reduction

Need for analytical techniques

Various authors have commented on the need for analytical techniques in systems work, as indicated by the following quotations--

To date our systems knowledge has been achieved by experience--by trial and error. The time is ripe for the development of a theoretical framework as a guide for larger systems analysis. At present the systems field is lacking a theoretical base . . . A corollary to the recognition of the need for systems theory is the growing acceptance that the work of the systems analyst is concerned with creating models of reality. . . . The very essence of analysis is the ability to select from, or abstract the significant factors from a complicated situation. . . . To date, such abstracting has been intuitive. Now we expect to see the development of techniques that will help us support intuition as we seek to isolate the important elements in a systems problem.4

The job of analyzing an existing data system is still a primitive process, and is a growing problem to the Air Force because in spite of this primitiveness the Air Force is and will be conducting numerous data systems of large, complex, and differing systems. Each study demands a great deal of time and manpower; and even after the system is fully documented and flow charted, the further problems remain of coping with the bulky and detailed data gathered and the lack of explicit directions for using the results.5

Although the electronic data processor has revolutionized data systems in the past decade, the cumbersome procedures for installing and operating them derive from the 19th century. The techniques for interviewing, documenting, flow charting, and analysis remain unchanged. The rationale for


determining what data to analyze and how to analyze them has changed little since the advent of the computer.  

During the documentation and systems analysis phases, the analyst is confronted with a large workload problem; he organizes flow charts and assimilates mountains of data. After a digestive process, he attempts to make a logical appraisal of the data characteristics, and eventually creates a "new" data system. Efforts to aid the analyst in this phase of the study are few. ........................................

In addition to the documentation and analysis phases, the system design phase suffers from the lack of a method for analytically arriving at the "best" system, i.e., one which considers the best mix or use of people, equipment, procedures, data, etc. Too often the emphasis on the electronic equipment distracts the designer from the even bigger problem of fitting the individual into the system. Like system analysis, system design is in a primitive state. The systems designed are based solely on the experience of the designer, and there are no fixed rules or techniques to help him. 

Although technology has produced electronic data processors, little progress has been made in the analysis and design techniques employed in systems effort.

**Large numbers of employees**

In a study dated 1954 of the ratios of staff to line employees, Baker and Davis reported that "40 percent of the employees in manufacturing were classified as indirect." Out of the 16 indirect classifications described in the study, 12 of these classifications involve the production and processing of information. Assuming a

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6 Ibid., p. 1.

7 Ibid., p. 6.

8 Alton W. Baker and Ralph C. Davis, *Ratios of Staff to Line Employees and Stages of Differentiation of Staff Functions* (Columbus, Ohio: The Ohio State University Bureau of Business Research, 1954), p.3.
linear proportionality, then three-fourths of the indirect employees or 30 percent of all employees are primarily concerned with the production and processing of information.

In 1958, McDonough, formerly the director of the Taylor Management Laboratory reported, "Half the cost of running our economy is the cost of information. No other field offers such concentrated room for improvement as does information analysis." These quotations are significant as indicators of the increasing emphasis placed on information by management and the need for this study.

Increased use of computers

In the last decade, there have been numerous investigations of methods to improve the processing and production of information. The majority of these investigations have been initiated due to the potential use of electronic data processing machine systems. To utilize electronic data processing machine systems effectively, several techniques have been devised to translate into machine language the source data generated by the various functions of an organization. By using a machine language common to all parts of the electronic data processing machine system, one achieves more effective utilization of the machine system in the processing of data. Such a common language approach is fundamental to a truly integrated data processing system in order to make as much use of data as possible.

The large size, complexity, and variety of Air Force data systems have caused continuing difficulties, and invite review of all the processes involved from

---

the initiation of a data system study to its implementation—currently, two to eight years, depending on the scope of the application.¹⁰

Data collection, translation, and processing are the activities closest to the computer and represent only a part of the business or management information system. The information requirements of the entire enterprise must be established. A master plan of the management information system must be developed and implemented. A primary control objective of the information system is to keep management informed of the status of actual accomplishments related to the planned accomplishments. All of these become parts of the management information system.

In 1960, just before the primary research of this study began, the Air Force Logistics Command inventory of computers included 19 large-scale computers and 35 medium-scale computers at a rental rate of $32 million per year.¹¹ Currently, the computer inventory of the Air Force Logistics Command includes 15 large-scale computers, 80 medium-scale computers and 10 small-scale computers.¹²

**Data reduction for management**

In 1956, Cordiner, president of General Electric Company, in presenting the communications challenge of his philosophy of management said--

> The development of measurements is important, but it is only one part of the immense problem of organizing

---

¹⁰Gatto, p. 1.

¹¹As reported in AMC Worldwide Nov/Dec 1960 issue, p. 4.

and communicating the necessary information required to operate a large decentralized organization to achieve defined objectives and known common purposes.

This deep problem of communication is not solved by providing more volume of data for all concerned, or even by faster accumulation and transmittal of conventional data, or by wider distribution of previously existing data, or through holding more conferences. Indeed, the belief that such measures will meet the communications [management information] challenge is probably one of the great fallacies in business and managerial thinking.

What is required, instead, is a far more penetrating and orderly study of the business in its entirety to discover what specific information is needed at each particular position in view of the decisions to be made there. 13

Thus, Cordiner suggests that one of the best approaches which the systems analyst can employ is to make a fundamental attack on the whole management information system, rather than a piece-meal attack on eliminating unnecessary or duplicate reports one by one. Most organizations, on occasion, undertake some type of a house cleaning effort aimed primarily at reducing administrative expense by eliminating the clutter and confusion from existing reports. In these circumstances, such a cost reduction effort can hardly ever achieve the objective of insuring that the management information system is providing the information needed by management to operate effectively and to determine how each segment within the organization is contributing to the organization's goals. As Neuschel, Director of McKinsey and Company, Inc., stated, "It is a fundamental premise . . . that the application of organized, intelligent, and continuing research to business procedures [systems] offers an unparalleled opportunity to improve the effectiveness

of the modern business organization." Neuschel seems to paraphrase Ralph C. Davis who stated, "Scientific management . . . is an approach which seeks to apply the logic of effective thinking, based on a management science, to the solution of business problems. . . . Effective, economical solutions of business problems require the practical application of a sound, logical management philosophy." 

Neuschel defines a management information system as a "network of related procedures developed according to an integrated scheme for performing a major activity of the business." Such networks can be viewed as communication networks which represent either a major activity within a business organization or the entire organization. These networks are seen in the flow charts of a system analyst. In order to represent the management information system, the systems analyst has broken the charts into segments corresponding to the various functions of the organization. The relationship of these segments is shown by still another chart which leaves out the details in each of the segments. The analyst now has a model of the management information flow of an organization by sections because "it is difficult to look at the total system in detail. Those diagrams which integrate the complete system of an enterprise have proven to be cumbersome and incomprehensible."


15Davis, p. 54.

16Neuschel, p. 10.

17An address presented by Irving J. Lieberman, Senior Research Staff, Litton Industries titled A Mathematical Model for Integrated
If the systems analyst is to make a fundamental attack on the whole management information system, as Lieberman indicated, he should build a model of the information system which has the ability to--

1. Present the entire system and its details in an easily understandable format.
2. Provide a method of manipulation to incorporate and test changes to the system.
3. Display all effects of such changes to the system.

It is the premise of this study that the grid charting technique provides such a model.

**Definitions of Terms Used**

There are terms that are particularly germane to every profession; the emerging field of systems activity is no exception. The increased use of computers in business has generated a host of new terms that is emerging as the language of the systems man. Evidence of this emergence is reflected in published glossaries. Almost every computer manufacturer has published a glossary of terms.

A complete list of the terms used in this study is given in Appendix B. A few of the more important terms are defined below.

**Basic record**: any document or form maintained periodically to record the historical status of business activities. Its primary
purpose is for reference only, such as inventory file, a personnel record, a payroll register, or an accounts receivable ledger.

**Data element**: a specific item appearing in a set of data; e.g., in the following set of data, each item is a data element: the quantity of an item, the unit price, and the balance on hand.

**Data system**: a large-scale information system of the United States Air Force that is automated and employs at least one computer as a processor.

**Decision logic tables**: rectangular arrays that portray related decision conditions to actions.

**Decision tables**: a shortened form for decision logic tables.

**Final report**: any document, form, or other paper used in management planning and controlling, or essentially decision making. The report should not require any further processing to be considered a final report.

**Fixed data element**: any data element, whose content is not subject to change over long periods of time such as an employee's social security number.

**Grid chart**: a matrix or rectangular array that portrays relationships between factors of information such as data elements, sets of data in reports, documents, basic records, source documents, punched cards, magnetic tape reels and/or various management functions or activities. Any medium that carries information may be represented in the array. The arrays may portray any combination of factors.

**Grid charting technique**: the combined use of grid charts and decision logic tables to represent a management information system.
Identification data element: any data element that describes or identifies a document, resource, or any other factor.

Intermediate record: any document basically internal to a processing system and used primarily to facilitate the processing of data rather than as a final report of the system. An example would be summary cards in a punched card system or work sheets in a manual system.

Level of indenture: the layered structure within a system.

Management information system: a network of related cycles of data flows which produces final reports from source documents for management control and planning of a business function or a set of activities.

Quantitative data element: any data element that gives a quantitative measure or value.

Source document: the form on which quantitative data first enter any information system.

System: an assembly of procedures, processes, methods, routines, or techniques united by some form of regulated interaction to form an organized whole; an on-going process.

Scope

As DaVinci once said:

It is my intention first to consult experience and then show by reasoning why that experience was bound to turn out as it did. . . . Although nature starts from reason and ends with experience, it is necessary for us to proceed the other way around, that is . . . begin with experience and with its help seek the reason.19

19 Leonardo DaVinci, Notebooks, circa 1500.
Since this dissertation dealt with the evaluation of the grid charting technique as a model for the analysis and design of large-scale integrated management information systems in the Air Force Logistics Command, the area of investigation was concentrated in that command and with its officers and civilian employees who attended the Fundamentals of Data Systems Analysis Course. The research investigation was structured not only to test their knowledge of principles and the technique but also the results attained by these students with the grid charting technique.

Organization of the Dissertation

The methodology utilized in this study is described in Chapter II. The theory of management information systems, including elements of the systems approach and systems concepts related to management and management principles, are described in Chapter III. This theory is the basis for the grid charting technique and for the primary investigation in this study. The entire grid charting technique is presented in detail in Chapter IV. The primary research conducted by questionnaires and interviews is analyzed in Chapter V. In this chapter, the experience of the students with the grid charting technique and with the theory of management information systems is presented together with some reasons for those experiences. Conclusions and recommendations are given in Chapter VI.
CHAPTER II

RESEARCH METHODOLOGY

Secondary Research

The development of the grid charting technique investigated in this study has encompassed a period of years, several tests and subsequent modifications. This chapter describes the genesis, development, and method of evaluation of the grid charting technique as a model of real world information systems.

The lack of theory and technique

As a member of a corporate systems team, responsible to develop and implement a corporation-wide integrated management information system, the author conducted a secondary data search for a theory of management information systems. The corporation library, The University of Buffalo Library, The Buffalo State Teachers College Library, and the City of Buffalo Library were visited. Interviews with senior professors were conducted at the University of Buffalo. This search revealed that a structured body of management information systems knowledge did not exist at the time and would have to be developed from basic concepts of management. The management concepts of Ralph C. Davis were selected as the basic foundation for the

1Directed by the president of Bell Aircraft Corporation, Buffalo, New York in 1956.
planning of management-information-system development efforts. These concepts were selected because they exhibited characteristics that lent themselves to abstraction and application. During this development phase, it was recognized that every manager is an inventory manager of some combination of resources. With his allotted inventory of resources, each manager must accomplish his delegated responsibility of producing goods and/or services to meet his objectives. As an inventory, two basic factors directly affected managerial performance: the quantities of each resource available to the manager and the nature of the demands placed by the customers or the consumers on the manager for goods and/or services. The ability to report status of those resources in relation to the actual and forecasted demands for goods and/or services is fundamental to the design of any management information system. Thus, the first concepts of management information systems evolved from the management concepts of Davis.

This secondary research also showed that techniques for analysis and design of information systems have not kept pace with the technological advances of the past two decades. The only new technique with promise was the Lieberman Mathematical Model.²

The first test

Research of the practical application of the Lieberman model was begun in conjunction with a feasibility study of the mechanization of status reporting for aircraft spare parts. Prior to this model, this management information system was recorded in flow charts using the

²Presented in a lecture to the Institute of Management Sciences in 1955; see Appendix A.
traditional four process chart symbols to display the flow of information. In attempting to evaluate modifications to the process by making changes in the flow charts, it was discovered that all of the effects of each change were not easily identified and in some instances were completely overlooked. A second problem emerged from the enormous but necessary detail in the flow charts. To maintain management interest, it was necessary to abstract from the detail and to develop less detailed flow charts. In so abstracting, the full impact of the amount of detail in the process and the total effect of a change were lost. The design requirements of the Lieberman model appeared to provide a more effective way to avoid these problems: "(1) the model presents the total system in an easily comprehensible form, (2) the model presents the details of the system, (3) the model has a method for manipulation, (4) the model shows the effects of system changes."^3,4

This mathematical model, as designed, was tested on the same management information system previously flow charted. The purpose of the test was to determine whether the model accomplished its design requirements in application. When the test was completed, some limitations of design were identified: (1) the assumption that all data elements entering the system flowed through the entire system was not

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valid, (2) the mathematics did not produce a sufficiently valid answer to justify the mathematical effort, (3) there was no definite order or philosophy to the listing of management or business functions and (4) there was no systematic approach to analyzing the matrices of the model. However, the matrix displays of the model readily revealed duplications in management action reports and in information that had not been revealed in the numerous flow charts of the original study. Thus the limitations were not serious.

The second test of the concepts and technique

The analysis of the personnel information segment of the corporation-wide management information system provided the opportunity for a second test of the Lieberman model. R. C. Davis' organic management functions, the inventory of resources concept, and a data element matrix of the Lieberman model were used to study the existing personnel operations and information flows as shown in Appendix C.

One large matrix was used successfully in this application as a substitute for the mathematical manipulation of data elements in the original model.

During this study, conducted in 1958, two new concepts were developed as the documents and data elements were segregated into three groups. These groups evolved from viewing the personnel function as one dealing with the inventory of human resources. As an inventory, only three basic transactions could affect the inventory status: (1) hiring, (2) change of status of people in the inventory, such as hourly to salary or union to non-union, thus changing either the personnel data or the data content and, (3) termination. Thus, the
concept of three basic transactions evolved. From the segregation of documents into three action or transaction areas and the subsequent construction of a large matrix display of data elements vs. the three document areas, the concept of fixed and variable elements of data emerged. Study of the matrix, after classification of the data elements into identification and quantitative, disclosed that some remained fixed, while others changed in form or content, through the personnel process. Thus, the matrix technique again was modified to classify data elements as fixed or variable similar to the classification of costs as fixed or variable in cost accounting. From such a display the refinement of the data elements was facilitated. This refinement replaced 32 different personnel forms with one basic personnel document in the new personnel management information system. Guided by Cordiner's communications challenge to management, the management concept of objectives of Davis, and application of the modified matrix display technique of the Lieberman model, the design of the new personnel management information system was completed. The new system achieved its design objectives of processing random surges of data caused by sudden shifts in employment. Random inquiries generated current data; data outputs flowed smoothly into the cost control, labor distribution, and payroll information systems. More accurate, timely reports were made available to management, with all investments recovered in six months.

The third test of the concepts and technique

The concepts of management information systems and the Lieberman model were taught to 98 students in five consecutive offerings of a
thirteen-week course in Logistics Systems Engineering. This course was developed and presented under the author's direction for Air Force officers and civilian employees at the School of Systems and Logistics, Wright-Patterson Air Force Base, Ohio. Prominent visiting lecturers participated in the course and numerous discussions were held with each concerning the lack of a theory and the need for new techniques to analyze and design information systems. Their many comments and suggestions concerning management information system concepts and the matrix display techniques proved invaluable.

In the last five weeks of each course offering, the students researched current Air Force logistic system problems. This research required the application of knowledge gained in the classroom for the solution of the assigned problem. Formal reports, prepared by the students, were published by the school for interested agencies. These research efforts provided the opportunity to test the logic of the concepts as a theory of management information systems and to test the usefulness of the original Lieberman model and its matrix display technique in large-scale Air Force logistics management information

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6 Such as Major General F. C. Gideon, USAF; Brigadier General L. Grossmith, USAF; Dr. Sam Alexander, National Bureau of Standards; Mr. Charles Phillips, Office of the Assistant Secretary of Defense; Mr. John R. Provan, Veterans Administration; Dr. Howard Aiken, Harvard University; Dr. Robert Brecht, Dr. Adrian McDonough, and Dr. John F. Lubin, University of Pennsylvania; Dr. Norman Barish, New York University; Dr. Irving M. Copi, University of Michigan; Dr. Edward L. Wallace, University of Buffalo; Dr. Richard Maffei, Massachusetts Institute of Technology; Mr. James D. Gallagher, Sylvania Electronic Corporation; Dr. Leon Gainen, RAND; and Mr. James Hendricks, Raytheon Corporation.
systems. These research efforts revealed a weakness of logic in the definition and classification of system characteristics. This deficiency was corrected by the addition of Stanford L. Oppler's classification of system elements. Optner's concept of a module also added a refinement to the inventory of resources concept. In using the Lieberman model for large-scale management information systems, student research revealed the same design limitations discovered in the first test conducted on a smaller system. For large-scale Air Force Logistics management information systems, these limitations became serious. The data element weakness of the Lieberman model was finally corrected by eliminating the matrix multiplication and adding another set of matrix displays to portray more accurately the data element relationships.

During this time period, continued study of the management concepts of Davis resulted in the development of abstract models of his concepts for the theory of management information systems. Additionally, the Davis organic functions of business provided the basis for the development of the four organic functions of information. These organic functions of information became a basic concept for the use of the matrix technique as a practical application of the theory.

The latest test of the concepts and technique

Instrumental to the conduct of this study was the establishment of the Directorate of Data Systems and their request for a three-week course on the Fundamentals of Data Systems to be offered to more than 600 analysts, programmers, and supervisors. After much deliberation

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with the appointed project officer, these objectives were named: (1) to teach a common concept or theory, (2) to present a set of standardized techniques for analysis and design, (3) to recognize an emerging profession and (4) to provide a common foundation for continued advanced education.

Continued secondary research, begun in 1956, bore fruit. To meet this need, Richard Canning's, *Electronic Data Processing for Business and Industry*, 1956, and Stanford Optner's, *Systems Analysis for Business Management*, 1960, were selected as the basic texts. Although not wide enough in scope, they were the most adequate texts available. Since the directorate had recognized a need for the standardization of the techniques and the concepts used in systems analysis and design, primarily due to its large size, the theory of management information systems and the matrix display technique described as the grid charting technique in Chapter IV were integrated into the course curriculum as major subjects. This course presented the opportunity to teach both developments to personnel directly involved in the analysis and design of large-scale management information systems. The passage of time would subject them to the ultimate test of results.

The first offering, presented to a class specifically selected to evaluate the course intensively, was a success because of the interest generated, the rapport and enthusiasm of the students, and the general feeling that all of the course objectives had been achieved. Nevertheless, two deficiencies were observed in the matrix display technique.

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8See letter from General Gideon to General Combs, Commandant of the Air Force Institute of Technology, in Appendix D, dated May 1961.
The first deficiency was the lack of a technique to display decisions clearly since narrative descriptions proved to be clumsy. The use of decision logic tables\(^9\) provided the way to display decision conditions easily in order to evaluate management information needs. Simultaneously, it was recognized that the use of the word matrix seemed mysterious and implied an extremely sophisticated technique to the students. Using a concept of communication to keep the message simple and recalling that almost everyone was familiar with grids on a map, the name grid charting technique was chosen to replace matrix display technique. Thus, the grid charting technique was born, a combination of two tabular graphic formats called grid charts and decision logic tables: (1) the grid charts to portray information flows to management functions and (2) decision logic tables to portray management information needs related to actions. A special seminar on decision tables was presented for the students who attended initial course offerings to assure their exposure to these changes in the grid charting technique.

A three-day executive seminar, October 30 to November 2, 1961, was conducted for the directorate staff to expose them to the concepts and techniques that were being taught to their analysts, programmers, and subordinate managers.

As of October, 1963, 24 offerings had been presented and 564 students had been taught the theory and principles of management information systems and the grid charting technique. Of this group, 461 students were assigned to the Air Force Logistics Command at the time.

\(^9\)Tabular analysis - the use of decision logic tables was developed by Burton Grad in 1958 as reported in Chapter IV.
they completed the course. Of the 461 students, 353 students were
assigned to Wright-Patterson Air Force Base, Ohio. In May, 1963, per­
misson was granted to evaluate the uses of the grid charting technique
by these 353 students.

**Primary Research**

The primary research of this study involves the evaluation of the
uses of the grid charting technique by the 353 students assigned to the
Air Force Logistics Command at Wright-Patterson Air Force Base who
successfully completed the Fundamentals of Data Systems Course. The
data gathering techniques employed in this research were a questionnaire
and personal interviews.

**Questionnaire**

As each class graduated, the students were advised of the
possibility of enlisting their help in research. With such a closed
population and with the majority having good integration of work
objectives, a good rapport was established with most of the students.

**Construction**

In August, 1963, questionnaire design was started. The
questionnaire was structured to identify such characteristics as (1)
the degree of usefulness of the concepts and the grid charting
technique, (2) the advantages and disadvantages of the technique in
application, (3) the modifications to the technique derived from the
applications and (4) the factors limiting the use of the grid charting
technique. The more important references used in the questionnaire
construction included *The Art of Asking Questions* by Payne, Research

Important guidelines or design criteria used were "phrasing of items to facilitate summarization of responses and possible precoding of the questionnaire"\textsuperscript{10} to use tabulating machine cards for summarization and analysis. Logical response relationships between questions were included in the design criteria. In November, 1963, the questionnaire was reviewed by six data systems managers. Three of the managers were selected from the Air Force Security Service outside the Logistics Command. This jury critically reviewed each question for content, adequacy, bias, ambiguity, relevancy, and stability and then the entire questionnaire for the same criteria. From this review, two questions were revised. A stratified random sample was selected to assure that responses were elicited from students still involved in information systems design and that they represented a cross section of the entire group. Although statistical computations indicated a sample of 10 was a reasonable size, sixteen questionnaires were personally delivered to 12 students in systems design, two students in systems review and two students involved in operational effectiveness review. Even though this research had been announced by top management of the command, a letter was attached outlining the purpose of the questionnaire validity test and giving instructions to the test participants. From the results of this test, including a tabulation of the answers, two questions were restructured and one question was eliminated.

**Distribution**

As a result of this test, it was decided that the questionnaire would be sent to all of the 353 students stationed at Wright-Patterson Air Force Base. Of the 353 students, 307 were still located on the base. The 46 remaining had transferred, retired, resigned, or could not be located for other reasons. The most pertinent characteristics of this group included grade levels ranging from GS-9 to GS-14, military ranks from Lieutenant to Lieutenant Colonel, and functional duties as primarily data systems analysts, programmers, and supervisors. Questionnaires were distributed through the internal mail distribution system with a letter of instruction to each student specifying a return date and mailing address.\(^{11}\) All of the students had been advised by management of the study, the questionnaire, and the possibility of a subsequent interview and were requested to cooperate.

**Questionnaire return**

Of the 307 questionnaires distributed, 226, or 74\(\%\), were returned in useable form. According to researchers in education, "it may be necessary to delete persons unduly irritated or those who have good reason for not responding; however, these names must be included in calculating percentages."\(^{12}\) On this basis, four persons refused to answer, three persons were on temporary duty elsewhere, and three persons were on sick leave thus increasing the return to 236 and the percentage of return to 77\(\%\).

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\(^{11}\) See Appendix E for the sample questionnaire and letter sent to the respondents.

\(^{12}\) Good, pp. 282, 83.
As shown in Appendix F, of the 226 respondents, 183, or 81%, of these students were directly involved in the analysis and design of information systems and 43, or 19%, were in some manner indirectly involved as users according to the class rosters. In February, 1964, when the questionnaire survey was completed, these proportions had shifted so that 165, or 73%, of the students were still directly involved and 61, or 27%, were indirectly involved in systems analysis and design.

Although some follow-up was made to encourage people to return their questionnaires, follow-up was not actively pursued; it was thought that to do so might create unrealistic answers.

Questionnaire analysis

The data in the 226 returned questionnaires were key punched into IBM punched cards and analyzed using an IBM 1620 computer. The computer was first programmed to compare answers to certain sets of related questions to test the validity of responses. A general sorting routine was programmed and numerous distributions of the 159 indicative pieces of data in each of the 226 questionnaires were processed with the 1620 computer and analyzed. To use the computer, over 200 hours were expended in programming, over 100 hours were expended in computer processing and over 100 hours were expended in listing and tabulating. This amount of analysis, quantitatively, would have been prohibitive using traditional manual methods.

Interviews

It was originally decided to interview only those students who had used the grid charting technique to gather more detailed data concerning
their personal experience in the application of the technique. As the questionnaire analysis progressed, it was decided to include for interview students who had not used the grid charting technique. This action was prompted by what appeared to be limited use of the grid charting technique by the respondents and to assure more detailed identification of the reasons for limited use or the limiting factors than could be discerned from the questionnaire.

**Purpose**

The purpose of the interviews was not only to test the accuracy of the respondents' answers but also to probe more deeply into the specific uses and applications of the grid charting technique. The analysis of the questionnaire was used to identify the areas into which the interviews would probe for more detailed information. For example, interviews were necessary to identify the succinct advantages or disadvantages of the technique experienced by the students in their applications and to identify the specific nonlimiting factors responsible for the application or the specific limiting factors causing nonuse of the technique. If the questionnaire revealed many students reporting modifications to the technique, more questions concerning the modifications would be asked of those students.

**Method**

In sampling techniques, perfect accuracy is not only unnecessary but also impossible. This becomes clear, when one considers other sources of errors besides the traditional sampling variations such as sample selection errors and interviewer bias. As Ferber and Verdoorn said--
All that is needed are results with a sufficiently high degree of accuracy to be of practical value. . . . Surveys yield information on the probable limits within which the true, unknown values for the population lie. The specification of these limits is a practical problem, depending on the judgment of those who are going to use the results. The sampling problem is to determine what sample size and sample design will yield results within these limits as economically as possible.\textsuperscript{13}

Therefore, a purposive, stratified, random sample of 60 names was selected from the 226 respondents. The sample contained 30 users and 30 nonusers of grid charts from all seven job codes, distributed in proportion to the response by organizational unit and selected randomly within each unit via a table of random numbers. Of the 60 students in the sample, 50 students were located and interviewed. The remaining 10 students were absent due to sickness, vacation or temporary duty in other locations. Although management had previously informed the respondents of the possibility of being selected for interviews, each responsible supervisor was notified one day in advance of the interviews to be conducted in his area. However, each individual was not made aware of his selection until he was approached by the author. The cooperation of all was evident because delays were incurred in only three interviews out of the fifty interviews conducted. Each interview was conducted leisurely. The interviewee was reminded of the purpose of the interview and was guaranteed anonymity of his answers to assure more truthful responses. Each interview was carefully guided using both structured and open ended questions. For example, each of the students who had reported his use of grid charts in the questionnaire

was asked if he used grid charts, the number or amount of use, the DSAP number of the system, the logistics functions involved, the expanded development time on each application, the number of people assigned to the application, the number of grid charts used, and the factors displayed in the grid charts. These questions served to validate the questionnaire data. Each user was asked to cite the advantages and disadvantages experienced with their use of grid charts, the limiting and nonlimiting factors experienced in their applications, and to make any other comments deemed pertinent to grid charts. The same pattern of questions was followed for decision logic tables. If the interviewee had not used grid charts or decision logic tables, he was asked to amplify on the reason stated in his questionnaire. Strategic injections of the single word questions, i.e., what, when, how, who, where, and why urged the interviewee into more spontaneous, free flowing answers and provided open ends to questions that were initially structured. Inadequate responses called for careful probing. To continue the thread of conversation, each interviewee was asked to comment on his offering of the course: what he liked and disliked, what speakers and subjects were most vivid, and what he would like to have included in a subsequent course. At the close of each interview, the recorded responses were identified with a code and the interviewee was thanked for his time. In one area, a supervisor attempted to question the author about the responses of his personnel. Needless to say, no information was offered and a strong response was made reminding him of the promises made to those who were interviewed. Thus, the validity of the responses were assured. The data gathered in these interviews were sorted into job code groups for analysis.
In Chapter III, a selection of concepts from the theory of management information systems pertinent to the grid charting technique are presented. Material included in the chapter provides a background of theory for the grid charting technique and indicates basic concepts taught to the respondents of the study.
CHAPTER III

THE THEORY OF MANAGEMENT INFORMATION SYSTEMS

The purpose of this chapter is to present the basic concepts of the theory of management information systems that were taught to the respondents of the study. Such presentation is necessary because of the newness of the field, the lack of theory in the field, and the lack of general understanding of the theory. In essence, material in this chapter was developed and presented to the students who were respondents in this study and constitutes the theoretical base of the grid charting technique. In presenting this theory of management information systems, an attempt will be made to render some plausible general principles about the environment and objectives of management information systems. These principles evolved by assembling a structured body of thought and adding to it.

In the experiments with the Lieberman model, two weaknesses continuously appeared: (1) There was no definite order or philosophy to the listing of the management or business functions and (2) there was no systematic approach to the analysis of the model. This chapter provides some guides for a definite order to the listing of management functions. The next chapter, Chapter IV, provides a systematic approach to the analysis of an information system.

The best concepts and techniques for business planning and control must be used in view of constantly increasing requirements and rising
operating costs. Effective coordination in an organization requires proper communication. Yet normal practice has isolated organization structure problems from communication problems of the same organization when they should be attacked simultaneously. Any change in the organization structure has an impact on the information system requirements and conversely any change in the content of an information system has an impact on the effectiveness of the organization structure. The challenge posed by this statement is that of blending into one analysis all of the responsibilities, authorities, information requirements, and data processes. This challenge is the same as that posed for the grid charting technique as a model for the analysis and design of management information systems. Such analysis and design is complex.

Systems Defined

In the last four years . . . a number of larger companies such as Westinghouse Electric Corporation, Radio Corporation of America, Proctor and Gamble Company, Western Union Telegraph Company, and International Latex Corporation have been experimenting with new integrated information processing systems and have been introducing new concepts of corporate organization as a result.

The emphasis in most of these systems has been in the integration of data to provide a total information system.¹

A total information and control system concept is so new that as yet there is no general agreement on definition. In general, there is agreement that all relevant information about a business is handled in a consistent manner and brought together in such a way that uniform rules can be followed in different parts

of the business, that information can be quickly collected, analyzed, or manipulated and quickly dispatched to the part of the business where it may be used to best advantage.  

This is the challenge posed for management when organization and information structures are studied for relationships that are critical for business success. The effect of this challenge has generated expanded efforts under the general heading of systems. Systems is a very elusive concept that shifts meaning between disciplines and professions. The phenomenon exhibits itself even within the ranks of the system analysts. For example--

... "anything that consists of parts connected together will be called a system."^2

"The term 'system' usually refers to a standardized procedure."^3

"The emergence of a broadening approach to the problem of designing equipment."^4

"A ______ system is a logical configuration of the significant elements in a selected problem area."^5

"When an on-going process is found, a system may be in operation."^6

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^2Ibid., pp. 9-10.


^4Davis, p. 744.


^6McDonough, p. 140.

^7Optner, p. 9.
The usual justification for such exercises results from a limitation of semantics. If one defines the word system broadly to cover all possible cases, the definition loses specific meaning and becomes difficult to relate to a particular discipline, profession, or body of knowledge. If a narrow or more restrictive definition is given, it will exclude known systems but has the advantage of facilitating recognition of a system in a particular discipline, profession, or body of knowledge.

**Classes of Systems**

Beer arbitrarily classified systems as deterministic and probabilistic. "A deterministic system is one in which the parts interact in a perfectly predictable way. A probabilistic system, ..., is one about which no precisely detailed prediction can be given."8 Within these two classifications, he cites three degrees of complexity: simple, complex, and exceedingly complex. For cybernetics, these classifications serve a worthy purpose but become inelegant in this form for management.

Dwyer, Chief, Navy Management Office, Department of the Navy, recognizing this problem said, "Systems can have a variety of objectives; however, there are two broad categories of systems, which are differentiated by purpose ... a technical system ... [and] ... a communication system."9

Technical System - concerned with manipulation of physical material ... [such as] plant layout of a shipyard, assembly-line techniques, or the arrangement

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8 Beer, p. 12.

of components in a guided missile. . . . Technical systems support physical operations such as manufacturing and procurement.

Communication System - concerned with transmission of information within an organization. . . . The system supports managerial functions such as planning, directing and controlling. . . . [It is] a major tool of management which enables it to arrive at decisions and transmit them throughout an organization.10

He also recognized the fact that "communication systems and technical systems cannot be neatly separated in actual practice--because managerial functions never exist in isolation."11 Managers do not plan, organize, and control in the abstract but do plan, organize, and control the performance of technical operations. "Similarly, communication systems do not support management in abstract--they assist management in the performance of specific tasks."12 To accomplish any specific task or group of tasks requires a leader: the higher the level in management, the greater is the dependence of the manager upon the information of the communication system because he is farther removed from the operations of the technical system.

By his definition, Dwyer accounts only for physical materials and excludes other resources of concern to every manager, namely people and capital assets. From a management point of view, a more universal classification of systems also differentiated by purpose is to recognize two general types: Resource Systems and Information Systems.

10Ibid.
11Ibid.
12Ibid.
Resource systems are concerned with people, material, and capital. These resource systems produce either goods and/or services, i.e., other resources to satisfy the wants or recognized needs of society.

Information systems deal in meaningful or useful data that represent the resources of the resource system. Management depends upon the information produced by the information system to manage effectively the resource system.

Since information is an abstract representation of resources and since resources in terms of total utility to the customer involve time, place, form, and possession utilities, in like manner the value of information to the manager involves time, place, form, and possession value. "The business executive usually talks about values rather than utilities."13

In keeping with the distinction made between separable and non-separable functions of management by Davis, managers do plan, organize, and control the performance of resource systems and depend upon the nonseparable function of communication via information systems to accomplish the decision-making function.

Thus, information as the abstract representation of resources is the product in the information system and supports the nonseparable management functions of communication and decision-making. The higher the management echelon, the more dependent is that echelon upon information because it is further removed from the resources for which it is accountable.

Drucker alludes to this in saying, "The manager has a specific tool: information. He does not 'handle' people; he motivates, guides, organizes people to do their own work. His tool--his only tool--to do all this is the spoken or written word or the language of number."14 Effective administrative leadership is dependent on the courage and ability of the administrator to "interpret the facts properly . . . and follow the course of action which they dictate."15

The ultimate goal of an effective management information system is to keep all levels of management completely informed on all developments in the business which affect them. To do this, the data processing personnel and those entering information into the system should know exactly what data to collect and which data to tabulate, and management on its part has the obligation to be able to write down its actual requirements for internal information.16

Defining the Management Information System

When an electronics engineer designs a total electronic system, his first task is to define the desired outputs of the system and the required inputs to the system making it possible to generate these outputs. The design of this complex system is generally done in its broadest concept in terms of black boxes. The design problem resolves the inner detail of the black boxes in such a manner that they have the proper transfer characteristics required by the input and output


specifications. The design job can then be broken down into the various levels of detailing the black boxes.

Each succeeding level of detail will be referred to as the indentured level of design, with the first level of indenture being the total system. This process is repeated until one arrives at a level where individual elements represented as black boxes conform to accepted standard elements. For example, if a total system is a Hi-Fi set, the level of indenture process would continue until one reaches the level where tubes are represented as black boxes and are accepted standard elements.

In other words, there is an indentured sequence of design levels in the designing of the system. At any given level in this indentured design sequence, the model that is built can be tested to see if the combination of components used will give the prescribed input and output characteristics. In electronic engineering, this modeling is done by describing mathematically the characteristics of the black boxes as a transfer function, whether this black box be used to represent a resistor, an entire Hi-Fi set, or any other component level in the indenture breakdown.

The design process can either be a breaking down of a black box into its logical elements, or the combination of known components into a black box. The first case consists of breaking one level of indenture into the next level down. The second case consists of building up from one level of indenture to the next. If the building up process were used exclusively, the number of possible combinations alone would be defeating. Actual engineering practice is a combination of both bottom up and top down processes.
The entire process of design of complex electronic circuits has been highly developed in recent years. The advances of the state of the art are due at least in part to the powerful analytic tools used. Electronic circuit flow diagramming is certainly one of the most widely used tools, and probably the most powerful.

When it comes to business systems, where there are far greater complexities and where analysis tends to mix the indentured levels, the analysis and descriptions are usually done in terms of words. In recent years, the introduction of the electronic computer into business has given rise to a much greater awareness that the business system itself can be flow diagrammed. It is probable that years before the computer came onto the scene systems analysts used flow diagrams; however, the tendency has been not to separate or even to describe separately the various types of flows that take place. In the tangible flow area, diagramming according to the traditional systems techniques used by systems and procedures people tends to mix the various indentured levels.

The process of analysis and the building of models of management systems can be done in analogous fashion to designing done by electronic engineers. Such a process involves the organic functions of Davis, the Optner Module taken from the black box concept of the electronic engineer, the concept of an inventory of resources, and levels of indenture in management and management information described in this chapter. The grid charting technique described in Chapter IV enables the analyst to describe the information contents of the black boxes at each level of indenture.
Levels of indenture

Every business enterprise is a cycle of events within which exist other cycles of events which are dependent one upon the other. The major or top level cycle in a manufacturing business is the circuitous route from investment in men, machines, and materials to production, then to distribution to yield a profit which is divided between the investors and reinvestment in the business. "There are three divisions whose presence is universal in a manufacturing organization: production, distribution, and finance."17

![Figure 1. The Organic Functions Cycle](image)

According to Davis, these are called organic business functions, an analogy taken from physiology, since the absence of any one of the functions would cause the death of the organism or the collapse of the concern. A more abstract set of definitions implied by Davis for these organic business functions is the creation of values, the distribution of the created values, and the provision for capital. Within these organic business functions, the management functions of planning, organizing, and controlling must operate and are accomplished by each

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17Davis, p. 207.
functional manager. Top management must not only plan, organize, and control the enterprise by managing groups but must also plan, organize, and control the dynamic factor interrelationships between functions.

For the management levels within each organic business function there exists a major cycle of activities and within it a composite of indentured or layered minor cycles of tasks and operations.

If we are to build an information system capable of meeting the requirements of . . . a modern business, we need to know the anticipated range and intensity of all items of data which may be introduced into the system. . . . The design of an adequate system presupposes a very complete knowledge of short and long-term plans, and of the creative potential of the business.18

If the information system is to provide information to the manager for control, then it must be well planned. An approach to planning is to view the organic business functions as cycles and to determine if such cycles contain the elements of control. "The function of control is to correlate and coordinate action in accordance with a plan."19 "Control depends fundamentally upon a comparison between the results attained and the goals [or objectives] sought. There can be no concept of control without goals, objectives, expectations, or plans concerning the outcome that the operations should produce."20


19Davis, p. 630.

The function of control is not only dependent upon planning but also upon the function of organizing. If resources cannot be organized according to the specifications in the plan, either the planning goals or the resource specifications must be modified or the control elements will be ineffective. Control in turn serves to determine whether the plans are being adhered to and acts where necessary either (1) to bring results into conformity with plans or (2) to generate a need to replan. These alternatives tend to increase the precision of the control process. The first exerts a force on the factor of actual accomplishment with a "conform-to-the-plan" effect. The second exerts a force to modify the factor plan with a "conform-to-the-actual-accomplishment" effect. These interrelationships may be graphically portrayed.

![Figure 2. The Management Functions Cycle within each Organic Business Function](image)

Once the information has served the control function, it may then be used as a basis for future planning by validating or refining the goals originally established in a prior planning cycle. This cycle is also subject to management by exception.

The important point that must be recognized is the existence of an on-going process. Even as economics deals with an on-going concern so
management deals with an on-going process. Any business viewed as an
on-going process will continue to survive so long as it provides the
values demanded of it by the society in which it exists. Within the
on-going process, information cycles can be identified for each
function at each level of management. These information cycles must be
properly interrelated between the levels of management they serve.
Each information cycle must be designed to meet the management infor-
mation requirements at each level. Thus integration of information
cycles can be accomplished when such cycles are properly interrelated
and when the entire information structure rests on the broad base of
information cycles at the lowest level of the organization.

This recognition of information cycles inherent in the management
process can be diagrammed as shown in Figure 3. Once management has

![Diagram of the Information Cycle]

Figure 3. The Information Cycle
reviewed its control reports, such reports may influence changes in management decisions and/or in the various plans. In this manner, implementation of established objectives or goals for each level of management can be evaluated if the information cycles are so time phased with operations that current and factual reports are generated. To accomplish this analysis phase, all business operations must be described in some systematic way.

The module concept

Modules make "analysis and problem solving easier and more effective because they fill the need of providing basic and elemental ways of describing all business operations, regardless of complexity or type."  

This part of the theory rests on the premise that there are striking similarities between the way physical systems and business systems function. The principles of systems engineering suggest that we can learn something about the way an effective business system should operate by using as a tool the analogy to a logically designed electronic system. 

From this premise, Optner broadly classifies systems as physical and nonphysical. "When man becomes the processor of a system his functions will be much more loosely executed than those of the machine in the physical system." For this reason, he describes industrial and business systems as incompletely structured or unstructured and physical systems as structured. For both, he identifies five system elements or properties and their characteristics in tabular form—

21 Optner, p. 19.
22 Ibid.
23 Ibid., p. 7.
A more convenient way to view these elements is borrowed from the design concepts of closed circuit control in electrical engineering. These concepts are reflected in the well known segments of a computer--

Figure 4. Computer Structure

The ability of the computer to operate without human intervention is the result of relating the segments in a logical design. A more
convenient way to look at system elements evolves from Figure 4 and is portrayed by Optner in this way.

![Diagram of basic module](image)

**Figure 5. The Basic Module**

It [is] called a module to emphasize how it reappears at many levels in the business organization. This module [is] used to describe the attributes of a very elemental subsystem or a very complex, high level [system]. It makes no exception of the type of data being processed or the type of processor being utilized. It provides a way of looking at the functional interrelationships which exist in any ongoing process. As such, it becomes valuable as an objective standard. Since we know every system has certain elements, it follows that we can look for the system elements when we suspect there may be a business system in operation.25

![Diagram of factory module](image)

**Figure 6. The Factory Module**

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25Ibid., p. 11.

26Ibid., p. 15.
Although deceptively simple as a single module, a factory includes many complex, interrelated systems such as production control, inventory control, quality control, accounting, and sales each of which could be diagrammed in this same way. Each of these systems would have subsystems which could be further analyzed into much more elemental subsystems until the most simple, basic steps were being described as inputs, processes, outputs, feedbacks, and controls.

A more useful application of the module for the systems analyst is to display the basic management factors\(^{27}\) for a business system.

![Diagram](image)

**Figure 7. The Basic Business System**

Note the addition of organized society, whose function is "to dictate the objective, purpose, or goal for which the system exists,"\(^{28}\) to the module. Such an entity, group, or individual is called a systems purchaser by Optner. "Every system without exception will have a system purchaser."\(^{29}\) The use of Optner's module to portray the business system is consistent with the Davis thesis that business objectives are

\(^{27}\)Davis, p. 8.

\(^{28}\)Optner, p. 51.

\(^{29}\)Ibid.
derived from organized society and provide a value that satisfies a want of that society. Organized society, as an external control, does exert forces on the internal system controls of policies, procedures, organization structure, and management decisions.

Again deceptively simple as a single module, the business can next be viewed as three separate interrelated organic functions or system modules at the next lower system level.

Figure 8. The Organic Functions Modules

By recognition of "the devolution of objectives, functions, responsibilities, authorities, and accountabilities" matched with the proper system elements in each module, a rigorous understanding of the contents of each module and the interrelationships between modules at each level of system can be developed. As functions break down into subfunctions, each of the subfunctions can be portrayed as a module and analyzed for the factors of devolution and its systems elements. Continued analysis of each subfunction will evolve another understanding of the contents of each module and the element interrelationships between modules at that subfunctional level. This process should continue down to the lowest operative level for a rigorous analysis and understanding of the resource and information systems in operation.

\[\text{CAPITAL} \quad \text{PRODUCTION} \quad \text{DISTRIBUTION}\]

\[\text{Figure 8. The Organic Functions Modules}\]

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\[\text{Davis, p. 219.}\]
Some Realities of Information Systems

Often systems analysts whose experience has been in certain phases have difficulty accepting a broader concept of systems and fail to project their thinking into larger systems. The trend to think of a computer when systems analysis is mentioned often leads to the mechanization of established procedures that may be useless and outmoded for current management needs. Limiting the scope of activity of the systems analyst to mechanistic information segments severely restricts the return on an investment in systems effort.

To meet the challenge of the broader concept of systems, there are certain dangers or realities of systems that the systems analyst must recognize in the analysis and design of management information systems.

The computer complex

The computer today has become a management status symbol in many instances. This is particularly noticeable at conferences and seminars where the participants tend to rank themselves by the size of computer in use in their organizations. Whether their information systems require a computer or whether the computer is used effectively in no way affects such ranking. In some instances, just having the largest computer on order is enough to place that representative in first place in the hierarchy. Using the computer as a management status symbol usually produces a chaotic search by the systems analyst for applications for the computer soon to be delivered. The results of such an illogical, irrational approach are poorly designed systems, automation of existing but obsolete procedures, and high operating costs.
It is often just as dangerous to base the acquisition [of a computer] on the command of a data-processing manager to whom a new installation can mean a glamorous but expensive prestige symbol. The principal benefit of such installations is . . . that the data-processing people can then attend technical conferences as full members of the fraternity.

Or, worse yet, the computer people sometimes end up attempting to assume the role of high priests to the brain which is going to radiate the "new way" to all when it "goes on the air." They ignore all people who have operating experience, and concern themselves with looking for a place to apply some new trick techniques.

Certainly it is fair to conclude that digital computers, properly handled, are clearly the greatest management tool to appear in many decades.31

When computers are selected after a thorough study of the data processing capacities needed by the management information systems, the computer complex is avoided.

Defining the boundaries

Although there is a general understanding of what a total integrated information system should accomplish, there is very little agreement on how to divide the total information system into its component information systems. In an attempt to integrate the data processing and to build a sufficient volume of data to justify the use of a computer, individual management information systems often cut across organization lines. In such instances, their is a tendency to make the boundaries of an individual management information system so large that its size alone makes its design complex, time consuming, and costly. The absence of a set of finite rules for defining the boundaries of information systems often subjects the systems analyst to

conflicts between system boundaries, the degree of information integration, and the diverse demands of management for information. These conflicts can be minimized by top management development of a master plan of the component information systems with their data interrelationships discretely defined for the total information system of the enterprise. The component information systems should encompass related management activities in manageable segments such as payroll and personnel, requirements planning and raw material inventory control, or distribution and production.  

Systems criteria—a management responsibility

As every weapon system must accomplish some set of operating requirements or system criteria, so must every information system accomplish its set of operating requirements or system criteria, such as providing management with timely, accurate, and concise information for control. These information criteria must be defined in quantitative terms to facilitate the measurement of system performance. In either case, the responsibility for establishing the list of criteria for each system is a responsibility of the system purchaser. The system purchaser of a management information system is management; therefore, management is responsible for establishing systems criteria.

A more subtle aspect of the criterion problem is the danger that the criteria adopted for a lower level system may be unrelated or inconsistent with higher level criteria. For example, management must not measure the inventory system on the number of dollars invested if

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32 For further examples see: F. L. Conlin, "EDP-A Tool in Manufacturing Control" (unpublished Master's thesis, School of Business, University of Buffalo, 1957).
the entire distribution system is measured on some level of customer service or measure the computer center on tons of paper printed if a management information system is measured on the accuracy and timeliness of relevant management information. Such criteria usually generate conflicts.

**Spillover or side effects**

Limited resources force time-phased implementation of management information systems. The ultimate objective of a total management information system is to achieve a balanced flow of information between each of the related management information systems. If such interrelationships are not identified, system design or design modifications may produce undesirable side effects in other information systems. The probability of incurring spillovers or side effects is directly related to the degree of data integration between management information systems. Such effects may be minimized if the data interrelationships are known and system design changes are tested prior to implementation. For example, when approximately 40 data elements were eliminated from an inventory information system to improve its efficiency, 13 important data elements disappeared from a financial information system because the data interrelationship had not been identified.

**External balance of capacity**

Capacity of a system refers to the level of effort or work that can be processed by an information system. External balance of capacity

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involves the matching of the capacity of a management information system to the fluctuating demands for information imposed on that system. When system capacity is larger than demands, service is excellent but underutilization of resources exists. When system capacity is smaller than demands, service is poor but effective utilization of resources exists. Fluctuating demands produce oscillations in the external balance of capacity of an information system. Forecasting of demands which are the criteria for setting of the system capacity is a management function and should not be abdicated to the systems analyst. The alternatives of choice for management are infinite in this case.

Internal balance of capacity

Within an information system, balance of capacity must be established between the subsystems or components of the information systems to achieve a balanced flow of information. Although bottlenecks in such flows are discovered easily, it is the opposite case that usually goes undetected. Excess capacity in a subsystem is often zealously protected to derive the praises and rewards of excellent services while avoiding the dangers of fluctuating demands incurred in other parts of the system. This part of the information system could deliver its information within two hours of a request because of its excess capacity, while other subsystems could require five days. An example is the computer that is used only three hours each day when an eight-hour-per-day rental is contracted.

Such is the succinct nature of the realities of information systems. The concept of the inventory of resources, discussed next,
provides some specific information design criteria to assist the systems analyst to identify and to avoid these realities of systems.

**Concept of the Inventory of Resources**

"Management often wants a management information system for the purpose of aiding the decision-making process. However, when the analyst tries to find out what information is required, at what levels, and by what managers, he often finds that management hopefully expects to be told what information they require to make valid decisions."\(^{34}\)

The purpose of this section is to provide some meaningful information design criteria for the analyst who finds himself in the position of being such an internal captive consultant to management.

The concept of the inventory of resources and its information design criteria have evolved from the traditional economic factors of production and the concept that information is abstract representation of economic resources.

The organic functions of any business can be portrayed as a cyclical flow, as shown in Figure 1 on page 40. Extending this concept, one can say that every functional manager is responsible and thus accountable for some combination of resources by which he is able to meet the demands of his customers. Resources, according to the earlier classification, include people, material, and capital; and customers may be internal and/or external to the organization.

The production manager, for example, with his accountable inventory of resources must meet the internal demands for goods imposed

by the distribution manager. The ability of the production manager to meet these demands is directly related to two limiting factors: (1) the nature of the demands imposed by his customers for his goods and (2) the inventory level of resources allotted to him. In a similar fashion other managers, such as the accounting manager, the sales manager, the office manager, the personnel manager, and the transportation manager, deal with their accountable inventory of resources to meet the demands of their respective customers.

In order to manage this inventory of resources effectively and efficiently, the manager must be provided with information that compares the present and future status of his inventory in relation to the present and projected customer demands. Inventory status as used here means the operational condition of the inventory of resources.

There are three basic actions that affect the operational condition of any inventory of resources: (1) additions to the inventory of inputs, (2) changes in form or place called status changes, and (3) deletions from the inventory or outputs to meet customer demands. These basic actions, together with the form, time, place, and possession utilities of the resources, provide a foundation for some management information criteria. These information criteria devolve from a basic management information need that every manager have access to information that reports the identification, the location, the quantity, and the quality of each of his allotted resources with respect to time in each of the three basic action areas. This operational condition of the inventory represents the status of the accountable manager's inventory. If such information is to serve a control function, each element or set of information that describes an actual condition must be compared to
the previously planned condition. Therefore, "with respect to time" as used here includes not only current status compared to current demands but also future status compared to projected demands.

An effective analysis of any information system requires an intensive and thorough study of such information needs for every management position at all management levels involved or affected by the information system under study. The results of such a study must include the determination of what information is needed, by what activities or functions, in what form and sequence, at what points in time, to make what kinds of decisions. The analyst must study not only the continuity of information flows but also the nature of each managerial decision if he is to be able to tell managers "what information they require to make valid decisions."35 The concept of the inventory of resources is an important keystone in the practical application of this philosophy of management information systems because the concept identifies the general information requirements of management. The next step is to build a model36 of the information system that displays both the flows of information to the various management functions and the specific management information requirements: a model that blends into one analysis all of the responsibilities, authorities, information requirements and data processes of a management information system. The grid charting technique discussed in the next chapter provides a method to build such a model for the analysis and design of a management information system.

35. Ibid., p. 3.
36. For further explanation on the usefulness of models see: McKean, pp. 4, 5.
CHAPTER IV

THE GRID CHARTING TECHNIQUE

This chapter discusses the grid charting technique in detail. Such detail is considered essential because (1) the grid charting technique is the central concept of this study, (2) the material in this chapter was presented to the students surveyed and is the basis for their use of the grid charting technique, and (3) the grid charting technique must be understood to evaluate its potentialities as a model of a management information system for information systems analysis and design. It is further believed that the contents of this chapter in themselves constitute a distinct contribution to knowledge. The content has evolved over a period of time and exists in no other published or unpublished form.

The grid charting technique is an analytical technique which may be used to display the data processes, information requirements, responsibilities, and authorities operating in a management information system. Its format is based on the premise that almost everyone is familiar with the many uses of tables and grid lines. The grid charting technique employs two tabular formats called grid charts and decision logic tables. The grid charts are used to display the flows of data through the data processes to the various business functions. The decision logic tables are used to display the information requirements by relating decision conditions to management actions within delegated
responsibilities and commensurate authorities. It is of special value in systems analysis and design when used to model a management information system. Analysis of the model may reveal deficiencies of the existing management information system. The model may be used to assure a more complete understanding of the system or to design a new management information system. A thorough understanding of certain fundamentals must be mastered to utilize the total capacity of the grid charting technique effectively.

Although grid charts were developed by this author from the work of Lieberman in late 1956 and used in systems studies as previously discussed in Chapter II, a U. S. Army Task Force simultaneously developed similar grid charts in their mechanization studies of the administrative activity at Fort Meade, Maryland.\(^1\) Decision logic tables were originally developed and used by the Integrated Systems Project at the General Electric Company's computer facility in Phoenix, Arizona, in 1957 under the name TABSOL.\(^2\) The use of decision logic tables for man-to-man communication in the grid charting technique was adapted from the later developments of decision logic tables made by Burton Grad.\(^3\)

On November 13, 1961, the Directorate of Data Systems, Air Force Logistics Command, issued an office instruction titled Systems Design

\(^1\)See: A Feasibility Study as conducted at Fort George G. Meade, Maryland by a Department of the Army Team, n.d., The Applications Study prepared by the Adjutant General's School, U.S. Army dated January 23, 1958 or An Approach to the Basic Techniques of Systems Analysis by Radio Corporation of America, n.d. This latter document is only a further explanation of the Army effort. The Army application of grid charts was not as extensive as described in this study.


\(^3\)See: Burton Grad "Tabular Form in Decision Logic" DATAMATION (July, 1961), pp. 22-26.
Tools and Techniques\(^4\) which included the procedures for completing a grid chart and touched lightly on the grid chart evaluation process. However, this directorate regulation did not include the more detailed use of grid charts and the integration and use of decision logic tables as developed and taught to students who were the subjects of this study.

The Functions of Information

Every information system generates final reports for management. These final reports must be generated from source data. Between the source data and the final reports is at least one basic record or set of data primarily used for reference. To facilitate the processing of data, intermediate summarized sets of data are used between the source data and the final reports. Thus all data in a system can be classified into one or more of four organic functions of information, based on the purpose served in the information system.\(^5\)

These organic functions of data are generally classified as final, intermediate, basic, and source; in a paperwork system, the following definitions would serve to describe these information functions--

**Final report:** any document, form, or other paper used in management planning or controlling, or essentially in management decision making. The final report should not require any further processing.

\(^4\)See Appendix G.

\(^5\)Adapted from the work of Ralph C. Davis, *Fundamentals of Top Management* (New York: Harper and Brothers, 1951), pp. 205-213. Davis says that organic functions are "functions in a field of business activity that are so vital business activity will cease unless they are performed." also Supra, p. 40.
Intermediate record: any document basically internal to a processing system and used primarily to facilitate the processing of data rather than as a final report of the system. An example would be summary cards in a punched card system or work sheets in a manual system.

Basic record: any document or form maintained periodically to record the historical status of business activities. Its primary purpose is for reference only, such as an inventory file, a personnel record, a payroll register, or an accounts receivable ledger.

Source document: the form on which quantitative data first enter any information system, attached to identification data.6

The Functions Code

To facilitate reference and cross reference, a numeric functions code may be used. Such a numeric code is: 0 = source document, 1 = basic record, 2 = intermediate record, and 3 = final report. For effective use, the same code must be used by each systems analyst in a team effort. Also, the code and functions must be applied within the boundaries or limits of the study. These two rules must be followed or the equivalent definitions lose their meanings. Each document will generally have one and only one code or function. Some documents will, however, have two codes. This only means that the same document serves more than one function. For example: A document may serve initially as

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6These definitions were originally developed from the definitions of the Lieberman Model shown in Appendix A in 1956. At that time, the terms used were Management Report, Processing Documents, Master Files and Source Documents. These were later modified by the definitions used in the Army Study, Supra, p. 50, in May, 1961.
a source document and later continue in the system as an intermediate record. For small systems such cases are rare and do not occur frequently.

For any paperwork system all documents, forms, and records can be classified by these functions. The following example will demonstrate how these classifications relate to a simple paperwork system.

The president of a small corporation decides the time has come to establish a material inventory control system for his expanding business and issues a directive that gives this responsibility to the warehouse superintendent. The superintendent is to procure and distribute requisition forms to the shop foremen, to establish and maintain stock records in the warehouse office, and to prepare and submit a monthly stock consumption report to the president. This system is to be implemented within one month.

Many departments requisition materials as needed. One may classify these requisitions as source documents. As the materials are issued, the warehouse office posts their stock records. At the end of each month a summary or intermediate record is prepared showing the amount and distribution of material. This summary is the basis for generating the consumption report demanded by management.

\[0 = \text{Source Document} \quad 1 = \text{Basic Record} \quad 2 = \text{Intermediate Record} \quad 3 = \text{Final Report}\]

Figure 9. The Material Inventory Paperwork Cycle
In the sequence of this report cycle, there exist document relationships similar to the links in a chain. Using Optner's module, such a chain of data processing activity can be represented as:

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Requisitions 1 Data Process 2 Stock Record 3 Data Process 4 Summary Worksheet 5 Data Process 6 Consumption Report
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Figure 10. The Material Inventory Information System

The document links or relationships can be easily identified as the necessary inputs to outputs for each data process step. For data process 1, the requisition is the input and the stock record is the output from that module. In data process 2, the stock record is the input and the summary worksheet is the output. In data process 3, the summary worksheet is the input and the consumption report is the output. These document input-output relationships, properly classified by their information functions, are the basic factors required to represent the material information system.

These document relationships are easily understood in a simple system. In reality, the systems analyst must collect the actual documents used in each part of the system as he learns each process step because systems today tend to be complex communications processes. Application of Graicunas' theorem not only to points of management contact but also to the channels of information flow and the document relationships quickly reveals the complex nature of any information.

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7 See Davis, Fundamentals, ..., pp. 276-77.
The analyst must study such a system by parts and be able to identify the proper document relationships between the parts. The paperwork survey form is a tool that assists the analyst in properly recording individual document relationships in an organized fashion.

**The Paperwork Survey**

An important phase of any paperwork survey is the ability to record each document input-output relationship within a process step in an organized manner to facilitate understanding of the information flows in a system. An important principle of flow charting is to follow one thing at a time. For the analyst, it is equally important to follow each document input-output relationship in turn within each process step or module as he interviews administrative personnel during the data gathering process.

If each document in turn is considered as an output from a module, then all other documents required to produce that particular output document become the input documents to that system module. These input documents contain data that in effect back up the output document. For each output document, the systems analyst must identify and record certain data characteristics. These characteristics should include the form number, form title, the using organization or office, the document authorization, the frequency of publication, the volume produced, the number of copies, the distribution recipients, the information function or document code, the sending organization or office, the interviewer's name, the interview date, and the name and title of the person interviewed. For each input document, the data characteristics should include the form number, the form title, the function or document code,
the authorization or prescribing directive, the action taken, and any other pertinent remarks. The systems analyst should use a paperwork survey form such as the input/output survey/analysis form as shown in Appendix G to assure collection of relevant document data characteristics. During the interview, the analyst should complete one survey form for each document and attach a completed copy of the document to the survey form. This procedure allows the analyst to record each document and its relationships separately and thoroughly. The systems analyst is now ready to transfer this set of document relationships to a master grid chart.

The Master Grid Chart

The master grid chart is a tabular display of all of the input-output document relationships brought together into a single module. A rectangular row-column format is used in the construction of a grid chart. Each output document listed in the upper half of a paperwork survey form is assigned to a column of the grid chart. Each of the inputs or back-up documents is assigned to a row of the grid chart. Using the Material Inventory Information System in Figure 10, the systems analyst would have completed three paperwork survey forms during his interviews. From these survey forms, the analyst would transfer certain relevant data to a master grid chart form as shown in Figure 11.

8See Appendix G for the Grid Chart Form.
Three Survey Forms

Master Grid Chart

Figure 11. Posting the Master Grid Chart

Construction of the Master Grid Chart

For each document input-output relationship, the number (1) is posted in the proper row-column square to indicate the document relationship. If no relationship exists, a zero is posted to show a positive negation of the document relationship. The analyst would continue to post these relationships until all survey forms had been accounted for in the system under study and the master grid chart would be completed. In essence, all documents listed in the upper half of the survey forms are posted to the column or output section of the grid chart and all documents listed in the bottom half of the survey forms are posted to the row or input section of the grid chart. The completed master grid chart should contain all source documents on the input side, all final reports on the output side, and the same set of intermediate documents on both the input and output sides.
An example of the dependence of the functions of information or document codes on the boundary or scope of the system and the impact on an accurate portrayal of the system in a master grid chart is first to consider the payroll system shown in Figure 12.

![Payroll System Diagram]

**Figure 12. A Payroll System**

By limiting the boundary of the system to the immediate processing of the payroll, only five documents and two information functions are involved. The payroll master file and the validated time card are the source documents and the paycheck, payroll register, and the financial manager's report are the final reports. The master grid chart of this system is shown in Figure 13.

If the system boundary is enlarged to include the personnel and timekeeping functions as shown in Figure 14, eleven documents and four document functions are involved. Due to this change, the time card now enters the system as a source document and moves through two separate and distinct intermediate functions when it is extended and then validated.
Note also that the payroll master file serves as a basic record. These changes in information functions resulted from enlarging the system boundary.

![Table]

<table>
<thead>
<tr>
<th>DOCUMENT CODE</th>
<th>3</th>
<th>3</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>END PRODUCTS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(End Processing Activities)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>INPUT DOCUMENTS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PAYCHECK</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PAYROLL REGISTER</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FIN. MGR. REPORT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VALID TIME CARDS</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>PAYROLL MASTER FILE</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

Figure 13. The Payroll Master Grid Chart

System boundaries often cut across functional and/or organization lines and it becomes necessary to define accurately the system boundary in the heading section of each grid chart. Figure 15 shows the master grid chart for the enlarged personnel/payroll system boundary. The master grid chart heading section must reflect (1) the area under study as the sub area, (2) the next larger or higher level system as the major areas, and (3) the organizations involved in the data processing as shown in Figure 15. Listing of the study area and the next larger system, of which the study area is a part, serves to remind the systems analyst of the interrelationships that must be studied to avoid the dangers of low level suboptimization.

The output section must reflect the various outputs of each processing step within the study area. Outputs by definition will include final reports, basic records, and intermediate documents. The
Figure 14. The Enlarged Payroll System
form title, form number, information function or document code, and the frequency of each output must be listed in the output section. Frequency or periodicity of each output document is important since documents that are processed on a weekly, monthly, or longer period cycle may appear to be basic records but actually are intermediate records.

<table>
<thead>
<tr>
<th>MAJOR AREA: PERSONNEL PAYROLL</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>SUB AREA: PAYROLL FUNCTION</td>
<td></td>
</tr>
<tr>
<td>ORGANIZATION: PAYROLL</td>
<td></td>
</tr>
<tr>
<td>FREQUENCY</td>
<td></td>
</tr>
<tr>
<td>DOCUMENT CODE ►</td>
<td>2 2 2 1 2 3 3 3</td>
</tr>
<tr>
<td>END PRODUCTS (End Processing Activities)</td>
<td></td>
</tr>
<tr>
<td>INPUT DOCUMENTS</td>
<td></td>
</tr>
<tr>
<td>0 PERSONNEL HIRE</td>
<td>1 0 0 0 0 0 0 0</td>
</tr>
<tr>
<td>0 CHANGES</td>
<td>1 0 0 0 0 0 0 0</td>
</tr>
<tr>
<td>0 TERMINATION</td>
<td>1 0 0 0 0 0 0 0</td>
</tr>
<tr>
<td>0 DEDUCTIONS</td>
<td>0 1 0 0 0 0 0 0</td>
</tr>
<tr>
<td>0 TIME CARD</td>
<td>0 0 1 0 0 0 0 0</td>
</tr>
<tr>
<td>2 PERSONNEL REGISTER</td>
<td>0 0 0 1 0 0 0 0</td>
</tr>
<tr>
<td>2 DEDUCTION REGISTER</td>
<td>0 0 0 1 0 0 0 0</td>
</tr>
<tr>
<td>2 EXTEND TIME CARDS</td>
<td>0 0 0 0 1 0 0 0</td>
</tr>
<tr>
<td>1 PAYROLL MASTER</td>
<td>0 0 0 0 1 1 1 1</td>
</tr>
<tr>
<td>2 VALID TIME CARD</td>
<td>0 0 0 0 1 1 1 1</td>
</tr>
</tbody>
</table>

Figure 15. The Personnel/Payroll Area Master Grid Chart
The input section must reflect every input that flows into each listed output of every processing step within the study area. Inputs by definition will include source documents, basic records, and intermediate records. The form title, form number, information function or document code, and the frequency of each input must be listed in the input section. Frequency or periodicity of each input document is important to assure that the input-to-output frequencies are in proper relationship and that the frequency cycle of the sub area under study is in fact in-frequency with the next larger or higher level system.

The existing input-to-output relationships are shown by placing a numeric one (1) in the proper square. If no relationship exists, a numeric zero (0) in the proper square gives positive evidence of the negation and tends to facilitate any test for completeness and accuracy. Such a test for completeness and accuracy of the master grid chart is discussed in the next subsection.

The Completeness and Accuracy Test

Every tool or technique should be subjected to some test of precision or accuracy in order to assure proper use and application. Such a test has been devised to determine the completeness and accuracy of the master grid chart. Every master grid chart must meet the following five test criteria—9

1. Final Reports (Coded 3) appear only in the output section of the grid chart. By definition, final reports do not require any further processing, do not generate other documents, and thus can only appear as the outputs in a grid chart.

9Adapted and modified from the criteria for grid chart analysis used in the Army study in May 1961, Supra, p. 58.
2. Source Documents (Coded 0) can only appear in the input section of the grid chart. By definition, source documents can not serve as the outputs from other documents and thus can only appear as the inputs in a grid chart.

3. The same Basic Record (Coded 1) may appear in either the input and output sections or in both sections of the grid chart. Basic records may be the inputs to other basic records, intermediate records, or final reports. Also basic records may be the outputs generated from source documents, other basic records, and intermediate records. Thus, the same basic record may appear as an input and/or an output in a grid chart.

4. The same Intermediate Record (Coded 2) must appear in both the input and output sections of the grid chart. Intermediate records are used in the preparation of basic records or final reports and serve as their inputs. Intermediate records are generated from source documents or basic records or other intermediate records and serve as their outputs.

5. Every final report (Coded 3) to be a final report must be traceable back to one or more source documents. In Figure 13, all final reports are immediately traceable back to the time card and the master file as the source documents. In Figure 15, the paycheck is the output from the validated time card and the payroll master record. The validated time card in turn is the output from the extended time card and the extended time card in turn is the output from the time card as a source document. All of the grid charts shown in Figure 13 and 15 meet these five criteria.

Test violations

Based on the above criteria, there are three grid chart error conditions that could result from certain violations:

1. Incompleteness, by a violation of criterion 5

2. Miscoding of document codes, by a violation of criteria 1, 2, and 4

3. Documents outside the study area, by a violation of criterion 5

All test violations should be resolved by first rechecking the grid chart construction and the paperwork survey forms. If the violation remains, then the analyst must check with the individual listed in his
paperwork survey from whom the information was obtained during the interview. One necessary precaution that greatly assists in avoiding such violations is to have the system boundary well defined.

A master grid chart serves only as a common collection point for all documents involved in a systems study; its format does not portray the sequence of documents easily. The next subsection describes the sequencing of the master grid chart to portray the sequence of documents through the system.

**Sequencing the Master Grid Chart**

The purpose of sequencing the master grid chart is to establish a more readable and usable display of the document flow through the system. The sequencing process divides the master grid chart into a series of smaller grid charts. Each of these grid charts will display a set of input-to-output relationships extracted, in sequence, from the master grid chart. To begin this sequencing process, a basic assumption must be made: that all source documents enter the system simultaneously. As the initial set of inputs, this set of source documents is related to a set of output documents. This initial set of input-to-output document relationships is displayed in the first sequenced grid chart. Following the logic that the outputs of one module become the inputs to the next related module, the second sequenced grid chart will use the outputs of the first grid chart as its inputs. The second set of input-to-output document relationships is displayed in the second chart. The sequencing process is continued until all the input-to-output document relationships in the master grid chart have been accounted for and sequenced. For example, the sequencing of
the master grid chart shown in Figure 15 would yield the three grid charts shown in Figure 16.

![Diagram](https://via.placeholder.com/150)

**Figure 16. The Personnel/Payroll Sequence Grid Charts**

In Chart 1, five source documents or the inputs are related to three intermediate documents or the outputs. The Chart 1 outputs become the inputs in Chart 2. The Chart 2 outputs become the inputs in Chart 3. Since there are ten inputs and eight outputs in the master grid in Figure 15, the same number of inputs and outputs must be accounted for in all of the sequenced grid charts in Figure 16. As a control, the sum of the inputs and outputs can be used to check the construction accuracy of the sequenced grid charts.

The sequenced grid charts readily display the interrelationships and interdependency among documents. In Figure 16, for example, the paycheck and payroll register depend on the payroll master and the validated time card. The payroll master depends on the personnel register and the deduction register. The personnel register depends on the personnel hire, personnel change, and termination documents. In turn, the deduction register depends on the deduction document. Thus, a
Incorporating the Business Functions

The next grid chart to be constructed is called a functions grid chart and portrays the relationships between the forms in the sequenced grid charts and the business functions in the management information system.

A function . . . is any phase of the work of the organization that is necessary for the achievement of any proper or required organizational objective. It should be possible to distinguish it clearly from other phases of the organization's work. It should be separable from other such phases. Thomas R. Jones points out that "by function is meant a group of logically related and interdependent activities." What is logical obviously depends on the purposes for which functions are separated from the original body of work, and grouped in work assignments.10

Each organizational element, great or small, must have its primary, secondary, or collateral service objectives. The functions of the group constitute the work it must perform to preserve, acquire, create, or distribute whatever values constitute its objectives. These functions break down into subfunctions and duties that may be assigned to subordinate groups and individuals.11

Since "the purpose of a [management information] system is to carry information to decision makers,"12 and decision makers derive their responsibilities from functions, it is necessary to show the

10 Davis, pp. 202-203.
11 Ibid., p. 218.
12 McDonough, p. 72.
relationships between all the forms in the system and the customers for those forms. These relationships are displayed in a functions grid chart.

The input section of the functions grid chart is made by listing the output sections of each sequenced grid chart and the input section of the first grid chart as shown in Figure 17.

The output section of the functions grid chart shows the organizational elements that either receive or are charged with the responsibility of retaining each of the documents previously listed in the input section. The organization elements should be ranked by level of indenture in the organization and be identified by the titles used in the existing organization structure. In Figure 17, the relationship between each document and organization element is indicated by the 1 or 0 notation in each square. The actual number of copies may be substituted for the 1 notation. For example, if the payroll register were produced with two carbon copies and the original plus one copy were retained by the Payroll Department, then the number 2 could be entered in the appropriate square indicating that the Payroll Department retained two copies of the payroll register. The combination of the three sequenced grid charts in Figure 16 with the functions grid chart in Figure 17 portrays the documentation flow to the functions or organizational elements in the information system. The next subsection describes the portrayal of the data element flows through the system. Such data element display represents the data content of the information system under study.
Incorporating Data Elements

The purpose of constructing data element grid charts is to identify the actual data element content of the system under study and to provide a basis for a critical analysis of that data element content.

To do this, it is necessary to differentiate, as Lieberman did, between the kinds of data elements and the quantitative measures of data elements. For example, name, date, address, straight time hours, overtime hours, and total hours are different kinds of data elements. The number of straight time hours worked, the number of overtime hours worked, and the number of total hours worked are quantitative measures.

\[13\text{See Lieberman, p. 4.}\]
of those kinds of data elements. Two different employees may work 
overtime hours, which is the same kind of data element, but there may 
be two different quantitative measures if one is a salaried employee and 
the second an hourly employee.

Thus, in the manner that Lieberman distinguished between two 
different classes of information, i.e., identification type and quanti­
tative type, each data element can be classified as an identification 
(i) data element or a quantitative (q) data element.

Identification data element: any data element that describes or 
identifies a document, resource, or any other factor.

Quantitative data element: any data element that gives a 
quantitative measure or value.

Prior to the construction of the data element grid charts, it is 
necessary to classify, as "i" or "q," all data elements shown on the 
forms originally collected during the interviews. Continuing with the 
personnel/payroll system, as shown in Figure 16, there are only four 
unique sets of documents in this system. A set of documents refers to 
the input or the output section of a grid chart. In Figure 16, since 
the output section of Chart 1 contains the same documents as the input 
section of Chart 2, only one set of documents is considered. For each 
of these four unique document sets, data element grid charts are 
constructed listing documents as the outputs and data elements as the 
inputs. The data elements are segregated with identification data 
elements preceding the quantitative data elements in the input section.
All data elements, both i's and q's, are listed as they occur, assigned

14Ibid.
a sequence number, and remain in the list until all data elements in the system are accounted for in the grid charts. To avoid the tedious job of transcription, the data element grid charts may be grouped using one input section of data elements as shown in Figure 18. All columns are totaled to show the number of data elements contained in each document. All rows are totaled to show the number of times the same data element is used through the system.

If other data element characteristics, such as the maximum length of each data element, the alphabetic and/or numeric classification, or whether the data element conforms to a standard form, are needed in the analysis, such characteristics may be included by simply adding another column to the input section for each characteristic. Such characteristics are generally required for automating an information system and they usually exist if the system under study is an automated system.

A more useful characteristic for evaluating data elements is taken from cost accounting. Just as costs are classified as fixed or variable, data elements should be classified as fixed or variable in relation to their frequency of change. For example, an employee's personnel number assigned as a permanent number remains a fixed data element. However, the employee's department number and his pay rate would be variable data elements if the employee was a union employee with company-wide seniority under changing levels of employment. All data elements of an information system can be classified as fixed or variable, and as identification or quantitative data elements.

The primary advantage of the identification and quantitative classification comes from the basic premise that management renders decisions on quantitative data elements related to identification data
### Table 18. The Personnel/Payroll Data Element Grid Chart

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<tr>
<th>Data Elements</th>
<th>Total Identification</th>
<th>Pay Date</th>
<th>Deduct AMT-Bonds</th>
<th>Deduct AMT-Savings</th>
<th>Hours Work</th>
<th>O.T. Hours</th>
<th>Sick Time Hours</th>
<th>Vacation Hours</th>
<th>Total Hours</th>
<th>Total Deduct-Bonds</th>
<th>Total Deduct-Savings</th>
<th>Document Count</th>
<th>Gross Pay</th>
<th>Total Gross Pay</th>
<th>Net Pay</th>
<th>Total Net Pay</th>
<th>Year to Date-Earning</th>
<th>Year to Date-FICA</th>
<th>Accrued - Bonds</th>
<th>Accrued - Savings</th>
<th>Accrued FICA Total</th>
<th>Accrued Bonds Total</th>
<th>Accrued Savings Total</th>
<th>Total Quantitative</th>
<th>Total Data Elements</th>
</tr>
</thead>
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<td>Year to Date-FICA</td>
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<td>Accrued - Bonds</td>
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<td>Accrued Savings Total</td>
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<td>Total Quantitative</td>
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<tr>
<td>Total Data Elements</td>
<td>15</td>
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</table>
elements and not just on identification data elements themselves. "It is just as important to know what to count as it is to know how to count. Even in chemistry, qualitative analysis precedes quantitative analysis." If any document contains too much identification data and not enough quantitative data, it may interfere with the efficiency of the system and may cause unnecessary data processing. This classification serves to identify data excesses, deficiencies, and duplications in the analysis of an information system, and it serves to avoid data excesses, deficiencies, and duplications in the design of an information system.

The primary advantage of the fixed and variable classification draws attention to the relative probability of errors in data elements. Fixed data elements are less prone to error because their content does not change. Variable data elements are more prone to error because their content does change. This classification serves to identify the data elements with the greatest probability of error in the analysis or the design of an information system.

Analyzing the Sequenced Grid Charts

An effective analysis of any information system requires an intensive and thorough study of the information needs for every management position at all management levels involved or affected by the information system under study. The results of such an analysis must include a determination of what information is needed, by what activities or functions, in what form or sequence, at what points in

time or frequency, to make what kinds of decisions. The analyst must study not only the continuity of information flows but also the nature of each managerial function in a logical manner. The sequenced document grid charts, the functions grid chart, and the data element grid charts provide the analyst a model of the information flows to the various management functions in the system.

Analyzing the Data Flows to Functions

In analyzing information flows, the functions grid chart identifies each document's recipient and the data element grid charts identify each document's data element content. The analyst may expose many information system deficiencies by comparing the functional objectives and assigned responsibilities of each recipient to the kind of data contained in the documents flowing to that recipient. For example, (1) the identification of activities not receiving data because these data were not included in the system design or were never known to exist in the system by those activities or (2) the identification of an activity that receives duplicates of another activity's information and its clerical operations because an interdependency of operations exists that has not operated satisfactorily. Another deficiency may be the disclosure of an informal "empire building" activity or function through which all data or documents must flow regardless of need.

The interrelationships and interdependencies of documents from source documents to final reports are revealed in the sequenced grid charts. The explicit document relationships or document flows can be easily traced. A long trail through many documents or a short trail through a few documents is quickly revealed and interrupted flows are
easily disclosed. A long trail may indicate the existence of unnecessary data processes in the system or may explain the existence of long process cycles.

Analyzing the Functions of Information

Additional analysis of the documents and data elements may be accomplished by the construction of four additional data element grid charts corresponding to the four information functions. Each of these grid charts would show all documents serving the same information function with their data element content. For example, in Figure 18, the first data element grid chart contains all of the source documents in the personnel/payroll system and their data elements. This chart shows that the three separate source documents originating in personnel contain the same data elements, i.e., Personnel Hire, Personnel Change, and Termination. These three documents could be combined into one document containing a preprinted space for checking the type of personnel action. Thus redundancy of data elements is quickly detected. For a personnel office, charged with the responsibility of the inventory of human resources, more identification data elements with very little quantitative data elements are to be expected in the personnel documents. As basic guides for analysis, the what, where, when, who, why, and how of journalism as well as the eliminate, resequence, and/or combine of work simplification may be employed throughout the analysis of the grid charts effectively.

16 Supra, pp. 59-60.
Advantages and Disadvantages of Sequenced Grid Charts

In general, the analyst is able to accomplish a more comprehensive analysis of the system because the total system with all the details is presented in a condensed form. The use of grid charts gives the systems analyst a laboratory capability to analyze an existing system or to explore alternate system designs easily. The ability to test the total effects of systems changes such as elimination, combination, or resequencing of documents and/or data elements is facilitated. Sequenced grid charts are ideal tools for the analyst to model information systems and to analyze and/or design information flows but they do not provide a capability to display or evaluate management decisions and information needs. Even traditional organization planning, which provides for the grouping of activities and functions that are incorporated in the decision-making conditions, does not provide a technique for evaluating management decisions and information needs. The use of decision logic tables provides a simple technique for the analysis of decision conditions and actions, and provides a method to portray easily and to validate each manager's information requirements. Thus, grid charts portray the supply of information and the decision logic tables portray the demand for information in the market place of management information systems. The second part of the Grid Charting Technique, the use of decision logic tables to evaluate management information requirements or needs is discussed in the next section.

Analyzing Management Decisions

Many writers have contributed to decision-making concepts, the classification of management decisions, and the decision-making process.
Of these, the ability to differentiate routine decisions from nonroutine decisions has been important to the systems analyst. More important has been the search for a way to document and communicate management decision conditions and actions.

Decision-making . . . involves much more than the final choice among possible courses of action. It involves, first of all, detecting the occasions for decision—the problems that have to be dealt with—and directing the organization's attention to them. It involves, secondly, developing possible solutions—courses of action—among which the final choice can be made. Discovering and defining problems, elaborating courses of action, and making final choices are all stages in the decision-making process. When the term decision-making is used, we generally think of the third stage, but the first two account for many more man-hours of effort in organizations than the third. Much more management effort is allocated to attention-directing functions and to the investigation, fact gathering, design and problem solving involved in developing courses of action than to the process of selection. Decision-making, defined in this broad way, constitutes the bulk of managerial activity.17

Urwick contributed the concept of the span of control and Davis proposed the psychological span of attention as a factor in the supervisory span. With the latest movement toward large scale integrated information systems and more centralized control, management's new concern is for a span of comprehension of the total system. Without a span of comprehension, the span of attention and the span of control may focus on the wrong courses of action and generate meaningless decisions.

In order for the analyst to identify and classify all of the decision conditions and actions, there must be a method of translating

complicated narrative statements into a simple tabular format. The following illustrates this point--

There are three young girls in one family that are the envy of the neighborhood. Roberta and Nancylynn take ballet lessons, while Marybeth prefers tap dancing. Nancylynn has the same petite figure as her sister, Marybeth. Roberta's serious moods contrast with Nancylynn's gay ones. Marybeth's black hair and black eyes blend well with her olive complexion and she is a chatterbox. Roberta's dimples often show as she plays the piano with the skill of an expert musician. Nancylynn's blond hair and blue eyes present quite a contrast to Roberta's brown hair and brown eyes; both girls have a fair complexion.

Can you describe any of the girls without reading the paragraph a second time? What data is missing? A simple data table containing the given information as in Figure 19 will help answer such questions.

<table>
<thead>
<tr>
<th>NAME</th>
<th>Roberta</th>
<th>Nancylynn</th>
<th>Marybeth</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIGURE</td>
<td></td>
<td>Petite</td>
<td>Petite</td>
</tr>
<tr>
<td>HAIR</td>
<td>Brown</td>
<td>Blond</td>
<td>Black</td>
</tr>
<tr>
<td>EYES</td>
<td>Brown</td>
<td>Blue</td>
<td>Black</td>
</tr>
<tr>
<td>COMPLEXION</td>
<td>Fair</td>
<td>Fair</td>
<td>Olive</td>
</tr>
<tr>
<td>FACIAL</td>
<td>Dimples</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PLAYS</td>
<td>Piano</td>
<td>Piano</td>
<td></td>
</tr>
<tr>
<td>CHARACTERISTIC</td>
<td>Serious</td>
<td>Gay</td>
<td>Chatterbox</td>
</tr>
<tr>
<td>DANCES</td>
<td>Ballet</td>
<td>Ballet</td>
<td>Tap</td>
</tr>
</tbody>
</table>

Figure 19. Two Dimensional Static Data Table
From this illustration, some of the advantages of tables over narrative style for comparative data display can be readily appreciated: conciseness and clarity is [SIC] achieved by classifying data; completeness is insured [SIC] by revealing areas where information is missing; meaningful relationships are recognized quickly and easily with the two dimensional structure.¹⁸

Although decision logic tables resemble other commonly known table formats, they are more versatile because they identify precise points of reference to determine an action under a variety of conditions, both static and dynamic. "The significant difference between tabular form and other methods is not in the notational scheme used but rather in the physical layout"¹⁹ of the tabular format.

The Emergence of Decision Tables

In November 1957, General Electric management chartered the Integrated Systems Project to make a comprehensive study of the decision-making and the information and material processing required to transform customer orders into finished products - a major part of the total business system for a manufacturing firm. The basic purpose of the project was to probe the potential for developing an automated business system.²⁰

During this study, the project group found that tens of thousands of elementary decisions were made in the manufacturing business everyday. All were necessary to guide activities. Some of the decisions were repeated many times each day for various sets of conditions. In attempting to record the logic of such a complex information system, the narrative, flow charts, and logical equations methods were used. Of these, Grad said--

¹⁸Grad, p. 22.
¹⁹Ibid., p. 24.
Narrative form, unfortunately, is often wordy, requiring prepositions, conjunctions, and other superfluous elements for readability; there is a certain lack of form and physical relation which may lead to inaccuracy and inconsistency if the user is not extremely careful. Flow charts require lines and connectors to show relationships; when these become too numerous, the logic may be difficult to follow and the layout may demand excessive space. Logical equations are symbolic and abstract as, for example, Boolean algebra applied to computer programming. The main limitations are the need for special skills and background to algebraically describe rules and the attendant difficulty in communicating equations in a business environment.

Shortcomings have encouraged systems analysts to take a harder look at other alternatives.21

So the search began for new methods and it bore fruit when it finally centered on computer programmers and their techniques.

Since the early days of computer development, programmers have used analytical tables to convert arguments into precise functional values; they have also employed matrix structure and notation to handle common information with relatively complex structure. In the past few years, however, there has been substantial interest in probing the potential applications of tabular form for recording the decision logic itself. . . . This exploratory work in developing decision tables has involved consideration of man-to-machine as well as man-to-man communication.22

The General Electric Project effort resulted in the development of TABSOL, a tabular man-to-machine system oriented language which included decision structure tables as an essential element. Mr. T. F. Kavanagh, Manager of Production Control Service, reported the following benefits--

Structure tables force a logical, step by step analysis of the decision. . . . Structure tables are easily understood by human beings regardless of their functional background. . . . Structure table format is so simple and straightforward that engineers, planners,
and other functional specialists can write structure tables for their own decision-making problems with very little training and practically no knowledge of computers or programming. ... Structure table errors are reported at the source language level, thus permitting the functional specialist to debug without a knowledge of computer coding. ... Structure tables solved automatically in an electronic computer offer levels of accuracy unequalled in manual systems. ... Structure tables are easy to maintain. Instead of changing all the precalculated answers in all the files, it is often only necessary to change a single value in a single table.\textsuperscript{23}

Many other organizations became interested and adapted this technique to fit their particular man-to-computer requirements.\textsuperscript{24}

**Basic Characteristics of Decision Logic Tables**

Decision logic tables, regardless of purpose, all exhibit the same basic characteristics. The basic characteristics described here are intended primarily to serve the purposes of man-to-man communication, and more specifically to facilitate communications between the systems analyst, the manager, and the programmer.

**The parts of a decision logic table**

The three main parts of a decision table are the table header, the body, and the rule header.

\textsuperscript{23}Kavanagh, p. 22.

\textsuperscript{24}For examples and further study see:


The table header.--the table header contains descriptive information which identifies the purpose or content of the table.

The body.--the body of a decision table contains four parts: the condition stub, condition entry, action stub, and action entry. These parts are separated by a quadrant arrangement using either heavy lines or double lines. The location of each part may be either horizontal or vertical. Figure 20 illustrates a horizontal arrangement and a vertical arrangement.

The rule header.--the rule header contains number assigned to the rows of condition-to-action entries in the lower half of a horizontal arrangement or the right half of a vertical arrangement.

Elements of a decision logic table

The five elements of a decision table are the stub, entry, conditions, actions, and decision rules.

The stub.--The stub contains the descriptions of either the conditions or actions to be included in the table.

The entry.--The entry contains an indication of the various combinations of conditions and/or actions included in a table.

The conditions.--The conditions section includes the stub and entry that defines the state of existence of a specific factor or set of factors. Conditions may consist of the presence or absence of a particular value or range of values, short narrative statements, a statement of relationship to other data or conditions, or a combination of these factors. Conditions may ask questions and they control the actions to be executed when these particular conditions exist. Each individual condition should be simple to assure accuracy of interpretations.
<table>
<thead>
<tr>
<th>TABLE HEADER</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONDITION</td>
</tr>
<tr>
<td>STUB</td>
</tr>
<tr>
<td>RULE</td>
</tr>
<tr>
<td>ENTRY</td>
</tr>
<tr>
<td>RULE</td>
</tr>
</tbody>
</table>

A Horizontal Arrangement

<table>
<thead>
<tr>
<th>TABLE HEADER</th>
<th>RULE HEADER</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONDITION</td>
<td>CONDITION</td>
</tr>
<tr>
<td>STUB</td>
<td>ENTRY</td>
</tr>
<tr>
<td>ACTION</td>
<td>ACTION</td>
</tr>
<tr>
<td>STUB</td>
<td>ENTRY</td>
</tr>
</tbody>
</table>

A Vertical Arrangement

Figure 20. Decision Logic Table Format
The actions.--The actions are the commands to perform specific operations or tasks and include the stub and associated entry. Within a single table, each action is executed in the order written and must be logically completed before a subsequent action is initiated. Actions are also used to control the sequence within a set of decision tables.

The decision rules.--The decision rules consist of a unique combination of conditions and the associated actions to be taken. In vertical format, rules are displayed in vertical or columnar combinations of conditions and actions. In horizontal format tables, rules are displayed in horizontal or row combinations of conditions and actions. Each column or row combination of conditions and actions in a decision table is called a rule. Each specific combination of conditions associated within a decision rule must be logically unique so that each rule is separate and independent of any other rule. A rule may also consist of only conditions or one condition with the required action referencing another table. This is generally referred to as a no-action rule. A rule establishes the relationship between a condition or a set of conditions and an action or a set of actions. Such a relationship is established or interpreted as: if a condition or set of conditions is satisfied, then the related action or actions are accomplished. Individual rules express an or relationship. Two or more conditions within the same rule bear an and relationship to each other.

The placement of conditions in a table may have a significant bearing on the efficient use of a table. Conditions arranged to present the most frequently occurring conditions in the first rule and the least
discriminating in the last rule will reduce the search time through the table and make it more efficient in use.

The types of tables

Decision logic tables are classified by the types of entries made in the condition and action elements of the table. There are four types of decision logic tables, i.e., Extended Entry, Limited Entry, Mixed Entry and Unconditional.

Extended entry tables.--Extended entry tables have a part of the condition or action description extended into the entry element of the table. The data in the entry may contain statements, words, or values related to or a part of the data in the stub as shown in Figure 21.

Limited entry tables.--Limited entry tables contain the entire condition or action statements written in the stub. Data in the entry are limited to asserting, reversing, or ignoring a condition and to executing an action as shown in Figure 22. Condition entries are limited to a Y for yes, N for no, and a blank for not applicable to that particular rule. Action entries are limited to a Y or X for yes and a blank for action not to be taken or not relevant to the particular rule.
SALES TABLE

<table>
<thead>
<tr>
<th>WITHIN CREDIT LIMIT</th>
<th>PAYMENT HISTORY FAVORABLE</th>
<th>SPECIAL APPROVAL GRANTED</th>
<th>CHARGE SALE</th>
<th>CASH SALE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rule 1</td>
<td>Y</td>
<td></td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>Rule 2</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>Rule 3</td>
<td>N</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Rule 4</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y</td>
</tr>
</tbody>
</table>

Figure 22. A Limited Entry Table in a Horizontal Arrangement

Mixed entry tables.--Mixed entry tables contain both limited and extended entries. The only restriction imposed on mixed entry tables is that the entire entry for an individual condition or action must be either limited or extended.

Unconditional tables.--An unconditionable table eliminates the condition element and contains only the action stub and entries. The unconditional table can be used to display the sequence of actions necessary to accomplish a given task or process.

The Value of Decision Logic Tables

Decision logic tables provide a unique method for the systems analyst to display decision parameters. In 1961 Grad reported these contributed values--

Clarity and Conciseness

Decision tables are easy to prepare, read, and teach to others; experience shows that non-programmers can learn to prepare satisfactory tables in less than a day. The amount of writing, or number of words, lines, and symbols used in describing complex decisions is reduced by 25-50% as compared to flow charts. For certain specific cases, problem statement and programming time combined have been reduced significantly.
Completeness

Tabular form allows effective visual review or desk debugging both by the analyst and the reviewer. There are fewer errors to start with since the analyst tends to catch his own mistakes; moreover, the reviewer will typically detect a high percentage of the remaining errors by visual examination. Finally, experience shows that with this foundation and suitable test problem construction, it is easy to rapidly detect the balance of errors during machine debugging.

Meaningful Relationships

Table structure serves to improve systems logic by aligning alternatives side by side. It also sharpens cause and effect understanding, so relationships which are accidental or incidental become clearer. Furthermore, actions based on similar or related conditions are apt to be drawn into the same table, making it easier to appreciate and consider dependent factors.

The evidence quoted on the advantages of decision tables for systems analysis and computer programming is based on actual study projects. Some of these studies even tested decision tables on various data processing machines.25

There are additional values in the use of decision tables related more directly to Management Information Systems.

Identifies information needs

Decision tables by their format relate conditions to actions. The presence of any document in the information system is a condition that should be related to an action. Thus decision tables relate the information contained in documents to the actions derived from delegated responsibilities. By having management identify the conditions necessary for each action, management information needs can be specifically defined.

25Grad, p. 25.
Identifies routine decisions

Decision tables that relate conditions to actions in mutually exclusive rules identify routine decisions. Non-routine decisions do not meet the requirement of a mutually exclusive action for each rule and cannot be displayed in a decision logic table. A non-routine decision may be made a routine decision by having a mutually exclusive action established by the responsible manager. For routine decisions, more efficient use of tables may be achieved by ranking the frequency of use or occurrence of each rule with the most frequently occurring rule listed as first. This advantage is lost when the frequency of use or rank constantly changes.

Identifies decision-making levels

A series of decision logic tables related to the levels of management in the information system identifies those decisions made at each level of management. From this identification, management may justify or modify the decisions made at each decision making or management level.

The Values Added by the Grid Charting Technique

The Grid Charting Technique, composed of grid charts to portray the supply of information and decision logic tables to portray the management information demands, provides a potentially powerful set of tools with which the systems analyst can model any management information system for analysis and/or design of that system.

The grid charting technique exceeds the design objectives of the Lieberman model, avoids the matrix multiplications, and still provides more values or advantages. There are several values.
1. The business system is presented in a condensed [model] form which enables the systems analyst to see the total system at a glance.

2. This condensed [model] form presents all the details of the system.

3. Alternative ways of designing the integrated business system can be tested and evaluated scientifically.26

4. A determination of what is extraneous data can be made more easily.

5. If there is a request for new information, a way to collect and report it, which minimizes the data processing, can be determined.

6. Total effects of systems changes can be determined without changing the [real world] system.27

7. Organization factors both formal and informal may be incorporated in the grid chart format.

8. Decision logic tables enable the systems analyst to document and define management decisions derived from delegated responsibilities.

9. Decision logic tables enable the systems analyst to separate routine and non-routine decision and to specifically define the information requirements of each manager.

10. Grid chart entries are not limited to documents but may also represent computer tapes, paper tapes, TWX messages, telephone calls, and any other information media as long as the function of the information is properly coded.

"The major problem in [management information systems planning and control is [has been] to find a way to integrate the communication process with the information requirements for financial and operational planning and control."28 The grid charting technique provides one way.


27Ibid., p. 183.

28Ibid.
The communication process can be portrayed by using grid charts to display the flow of information via documents, computer tapes, and data elements to the various functions, activities, and tasks. The management information requirements can be established by using decision logic tables to display the relationships between the decision conditions and the associated actions and thus establish the management information needs.

When a system analyst is limited to the analysis and design of an information system to meet rigid management wants or desires, he needs only grid charts to model the information system because he has been limited only to the supply of data. All management information needs may not be satisfied because the systems analyst cannot guarantee that all management information requirements are satisfied and he runs the risk of a poorly designed system. Businesses and systems analysts may fail because they won't, don't, or can't investigate their customers' needs. A customer could have a need and never recognize it or may have a want and never satisfy it. When a supply matches the demands, an effective and efficient system is in operation. Decision logic tables may be used by the systems analyst, who must analyze management information wants and needs, to define more realistic management information demands. The use of grid charts alone may generate some improvements in data flows to the various management functions. More important, the systems analyst can design a more effective and efficient management information system by first comparing the demands for information portrayed in decision logic tables to the supply of data portrayed in grid charts and then designing the information flows to meet the specified demand. Fundamentally, how the analyst uses this
technique or any part of it depends upon the limits set for him by management and the capability of the analyst himself.

The next chapter, Chapter V, discusses the primary research data gathered from the 226 respondents in this study.
CHAPTER V

ANALYSIS OF THE PRIMARY RESEARCH

The primary research of this study was designed to evaluate the grid charting technique as a model for the analysis and design of large-scale integrated management information systems. The scope of the primary research included the concepts of the management information systems theory because the technique devolved from the theory. The data collection methods utilized were a mail questionnaire followed by selected personal interviews. Four specific research objectives were established to assure that questions were made clear, simple, and concise. The four objectives were--

1. To measure the usefulness of the concepts in the theory of management information systems and the grid charting technique as experienced by the students.

2. To identify the advantages and disadvantages of the grid charting technique experienced by the students in their applications.

3. To identify modifications to the grid charting technique made by the students in their applications.

4. To identify factors limiting the use of the grid charting technique by the students.

The questionnaire design was patterned from the module elements of input, process, and output. The concepts and grid charting technique
were the inputs to the students, they used the concepts and the technique in the process of their work and the value of the education would be reflected as the output. Accordingly, the questionnaire was designed primarily to measure the value of the concepts, to measure the degree and areas of application of grid charts and decision logic tables, to identify the advantages and disadvantages of the applications reported, to identify modifications to the technique in the applications reported and to measure the value of the education to the students. Structured answers were used to minimize the amount of time required to complete the questionnaire.

Although the modeling technique of this study has been described as the grid charting technique, the respondents in this study refer to the use of grid charts as the grid charting technique and to the use of decision logic tables as tabular analysis in their jobs, this, a result of having only grid charts described in their procedure. For this reason, it was necessary to refer to the use of grid charts as the grid charting technique and to the use of decision logic tables as tabular analysis in the questionnaire.

After receipt of 226 questionnaires, the answers were key punched and sight verified, an IBM 1620 FORTRAN General Sort Computer Program was written, and the answers were tabulated. A stratified random sample of 60 students was selected from the 226 respondents for personal interviews. These interviews were conducted to collect more specific information about the use and nonuse of grid charts and decision logic tables and to assure more detailed identification of the limiting and

1See MCBOI 500-11 in Appendix G.
nonlimiting factors that influenced such use and nonuse than could be discerned from the questionnaires.

Analysis of the Questionnaire Data

The analysis of the questionnaire data was limited to those questions within the scope of research objectives that dealt with the concepts in Chapter III, the grid charts, the decision logic tables, and the value of the education.\(^2\)

Specifically, Questions 13, 14 and 15 focused on the contributions and the informational values of the concepts of management information systems in Chapter III. Questions 18 to 21 probed the degree of use of grid charts, the areas of application, the factors represented in the grid charts, and the limiting factors of the applications reported. Questions 22 to 24 probed the degree of use of decision logic tables, the areas of application, and the limiting factors of the applications reported. Questions 25 and 26 concentrated on the value of the education. From this pattern, the relevant questions were grouped into four categories as Concepts, Questions 13 to 15; Grid Charts, Questions 18 to 21; Decision Logic Tables, Questions 22 to 24; and Value of the Education, Questions 25 and 26.

For the first questionnaire analysis, the answers were tabulated to show the distribution of responses to each question.

For the second questionnaire analysis, the answers were tabulated to show the distributions of responses by job description\(^3\) to each question.

\(^2\)See questionnaire in Appendix E.

\(^3\)Ibid. Question 3.
Questionnaire Summary

In this phase, the answers from the 226 questionnaires were tabulated to show the number and percentage distributions of responses to each question. The results of these distributions were grouped into the four categories, i.e., Concepts, Grid Charts, Decision Logic Tables, and Value of the Education for the following analysis.

Concepts - questions 13-15

Optner concepts - questions 13 and 14

The questions were structured to measure the value of the Optner concepts. Of the 226 respondents; 138, or 61%, replied that "Optner's module had been useful in their work." Also 121, or 54%, indicated that "Optner's classification of systems as structured and nonstructured provided some insights to the problem areas in systems."

Systems concepts - question 15

This question was structured to measure the informative value of eight management information systems concepts presented to the respondents. Every student was asked if the "lectures on the realities of systems were enlightening" regarding each of the eight concepts. As shown in Table 2, the "systems criteria concept" was ranked as the most informative concept since 183, or 81% of the students, marked that item "yes." The "external balance of capacity" concept was ranked the least informative concept in the "yes" column as indicated by 126, or 56% of the students. The same concepts ranked first and last in the "questionable" column in terms of the least "questionable" response being the most informative concept and vice versa. In terms of the most
informative concept having the smallest "no" response and vice versa, the "systems criteria" concept was ranked most informative but the "computer complex" was ranked least informative. More than 50% of the students indicated that the lectures on these concepts were enlightening.

TABLE 2
SYSTEMS CONCEPTS RANKED

Question 15 - Were the lectures on the realities of systems enlightening regarding:

<table>
<thead>
<tr>
<th>Concept</th>
<th>Blank</th>
<th>Yes</th>
<th>No</th>
<th>Ques.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>#</td>
<td>%</td>
<td>#</td>
<td>%</td>
</tr>
<tr>
<td>Systems criteria</td>
<td>5</td>
<td>2</td>
<td>183</td>
<td>83</td>
</tr>
<tr>
<td>Defining boundaries</td>
<td>8</td>
<td>4</td>
<td>175</td>
<td>77</td>
</tr>
<tr>
<td>Lack of standard definitions</td>
<td>7</td>
<td>3</td>
<td>174</td>
<td>77</td>
</tr>
<tr>
<td>Spillover or side effects</td>
<td>9</td>
<td>4</td>
<td>141</td>
<td>62</td>
</tr>
<tr>
<td>Computer complex</td>
<td>8</td>
<td>4</td>
<td>141</td>
<td>62</td>
</tr>
<tr>
<td>Lack of theory</td>
<td>10</td>
<td>4</td>
<td>138</td>
<td>61</td>
</tr>
<tr>
<td>Internal balance of capacity</td>
<td>9</td>
<td>4</td>
<td>127</td>
<td>56</td>
</tr>
<tr>
<td>External balance of capacity</td>
<td>9</td>
<td>4</td>
<td>126</td>
<td>56</td>
</tr>
</tbody>
</table>

Grid charts - questions 18-21

These questions were structured to measure the value of the grid charting technique, as a tool, to represent an information system, to measure the amount and areas of use of grid charts, to identify the factors represented in grid charts, and to identify some limiting factors of application. As noted earlier, the grid charting technique refers to the use of grid charts only in the questionnaire.

As shown in Table 3, concerning the value of "the grid charting technique, as a tool, for representation of the system," 175 or 77%, reported the technique "interesting," 138, or 61%, as "time well spent,"
and 107, or 47%, as "useful." These were responses made before the respondents had to indicate whether they had used grid charts and were expected to be optimistic. As shown in Table 4, 73, or 31% of the students "used" the technique. Of the 31% who "used" the technique, 8% reported a one-time use, 8% a two-time use, 4% a three-time use, 1% a four-time use, and 10% a more-than-five-time use. If the more-than-five is assumed to be a six-time use, then 234 grid chart applications were made by the 73 students who used grid charts.

**TABLE 3**

**VALUE OF THE GRID CHARTING TECHNIQUE**

<table>
<thead>
<tr>
<th>FACTOR</th>
<th>BLANK</th>
<th>YES</th>
<th>NO</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>#</td>
<td>%</td>
<td>#</td>
</tr>
<tr>
<td>Interesting</td>
<td>21</td>
<td>9</td>
<td>175</td>
</tr>
<tr>
<td>Time well spent</td>
<td>21</td>
<td>9</td>
<td>138</td>
</tr>
<tr>
<td>Useful</td>
<td>31</td>
<td>14</td>
<td>107</td>
</tr>
</tbody>
</table>

**TABLE 4**

**AMOUNT OF GRID CHART USE**

<table>
<thead>
<tr>
<th>Times Used</th>
<th>Respondents</th>
<th>Number of Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>153</td>
<td>68</td>
</tr>
<tr>
<td>1</td>
<td>19</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td>19</td>
<td>8</td>
</tr>
<tr>
<td>3</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>more than 5</td>
<td>23</td>
<td>10</td>
</tr>
<tr>
<td>more than 0</td>
<td>73</td>
<td>31</td>
</tr>
</tbody>
</table>
The respondents who used grid charts were asked to answer Question 20. This question was structured to measure the functional area frequency of grid chart use, to measure the values of grid charting indicated by those students, and to identify the factors represented in their application. These respondents reported that grid charts had been used in 47 DSAP\textsuperscript{4} numbered data systems. The logistics functions involved in these applications were supply, 45 times; maintenance, 17 times; comptroller, 11 times; personnel, 5 times; and plans, 3 times.

Since inventory management is the primary activity of the Air Force Logistics Command and is the primary responsibility of its supply function, the high involvement of the supply function was expected.

For the values of grid charting, Table 5 shows that 61, or 27\% of the

\begin{table}
\centering
\begin{tabular}{|l|c|c|c|c|c|}
\hline
\textbf{FACTORS} & \textbf{BLANK} & \textbf{YES} & \textbf{NO} & \textbf{QUES.} \\
\hline
Facilitate analysis & 157 & 69 & 61 & 27 & 4 & 2 \\
Facilitate design & 171 & 75 & 34 & 15 & 13 & 6 \\
Need to modify & 159 & 70 & 41 & 18 & 23 & 10 \\
Useful & 162 & 72 & 58 & 26 & 3 & 2 \\
Worth the effort & 165 & 72 & 52 & 23 & 2 & 7 \\
\hline
\end{tabular}
\caption{VALUES OF GRID CHARTING}
\end{table}

students reported that it "facilitated their analysis," 26\% felt it was "useful," 23\% felt it was "worth the effort," 15\% reported that it

\textsuperscript{4}Each large-scale automated information system in the United States Air Force is called a data system and is identified with a data system automation program number referred to as a DSAP number. However, all automated data system applications are not numbered.
"facilitated their design," and 18% felt a "need to modify"\(^5\) the technique. In these applications, the students were asked to identify the factor relationships displayed in their grid charts. The factors listed in the questionnaire were "reports and/or documents," "related management functions," and "data elements." From Table 6, for the students who used the technique, 53, or 23% reported that their grid charts displayed relationships between "reports and documents," 53, or 23% between "reports and data elements," and 29, or 13% between "reports and related management functions."

**TABLE 6**

GRID CHART FACTORS

<table>
<thead>
<tr>
<th>Factors</th>
<th>Blank</th>
<th>Yes</th>
<th>No</th>
<th>Ques.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td># %</td>
<td># %</td>
<td># %</td>
<td># %</td>
</tr>
<tr>
<td>Documents</td>
<td>162  72</td>
<td>53 23</td>
<td>11  5</td>
<td>0  0</td>
</tr>
<tr>
<td>Related mgt. functions</td>
<td>166  77</td>
<td>29 13</td>
<td>31 14</td>
<td>0  0</td>
</tr>
<tr>
<td>Data elements</td>
<td>163  72</td>
<td>53 23</td>
<td>10  4</td>
<td>0  0</td>
</tr>
</tbody>
</table>

The respondents who had not used grid charts were asked to answer Question 21. This question was structured to identify their reasons for not using grid charts. Of the 153, or 68% that reported no use of grid charts (Table 4) 150, or 67% reported a "reason" as shown in Table 7.

Of the 67%, 121, or 54% reported "no opportunity to use," 2, or 1% reported that they were "requested or directed not to use the technique" and 27, or 12% reported "other."

\(^5\)The nature of these modifications was questioned during the interviews conducted and is discussed in that section of this dissertation.
TABLE 7
GRID CHART LIMITING FACTORS

<table>
<thead>
<tr>
<th>Factors</th>
<th>$</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>No opportunity to use the technique</td>
<td>121</td>
<td>54</td>
</tr>
<tr>
<td>Requested or directed not to use the technique</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Other</td>
<td>27</td>
<td>12</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>150</td>
<td>67</td>
</tr>
</tbody>
</table>

Question 21 - If you have not used the grid charting technique, identify the reason.

Decision logic tables - questions 22-24

These questions were structured to measure the amount of use of decision logic tables, to measure the values of decision logic tables, and to identify any limiting factors of application.

As shown in Table 8, 38, or 16% of the students used decision tables. Of this 16%; 5% reported a one-time use, 5% reported a two-time use, 1% reported a three-time use and 4% reported a more-than-five-time use. If the more-than-five is assumed to be a six-time use, then 109 decision table applications were made by the 38 students who used decision tables.

Those respondents who used decision tables were asked to answer Question 23. This question was structured to measure the values of decision tables. Table 9 shows that of the 38, or 16% of the students, who used decision tables; 15% reported that it "facilitated their analysis," 16% felt it was "useful," 15% felt it was "worth the effort,"
12% reported that it "facilitated their design," and 8% felt a "need to modify" the decision table structure.

TABLE 6

AMOUNT OF DECISION TABLE USE

Question 22 - How many times have you used the decision tables or tabular analysis?

<table>
<thead>
<tr>
<th>Times used</th>
<th>Respondents</th>
<th>#</th>
<th>%</th>
<th>Number of Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>189</td>
<td>84</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>12</td>
<td>5</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>12</td>
<td>5</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>1</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>more than</td>
<td>5</td>
<td>4</td>
<td>60</td>
<td></td>
</tr>
<tr>
<td>more than</td>
<td>0</td>
<td>16</td>
<td>109</td>
<td></td>
</tr>
</tbody>
</table>

TABLE 9

VALUES OF DECISION TABLES

Question 23-2 to 23-4

<table>
<thead>
<tr>
<th>Factors</th>
<th>Blank</th>
<th>Yes</th>
<th>No</th>
<th>Ques.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td># %</td>
<td># %</td>
<td># %</td>
<td># %</td>
</tr>
<tr>
<td>Facilitate analysis</td>
<td>187</td>
<td>83</td>
<td>33</td>
<td>15</td>
</tr>
<tr>
<td>Facilitate design</td>
<td>188</td>
<td>83</td>
<td>27</td>
<td>12</td>
</tr>
<tr>
<td>Need to modify</td>
<td>189</td>
<td>84</td>
<td>18</td>
<td>8</td>
</tr>
<tr>
<td>Useful</td>
<td>187</td>
<td>83</td>
<td>36</td>
<td>16</td>
</tr>
<tr>
<td>Worth the effort</td>
<td>188</td>
<td>83</td>
<td>33</td>
<td>15</td>
</tr>
</tbody>
</table>

The respondents who had not used decision logic tables were asked to answer Question 24. This question was structured to identify their reasons for not using decision tables. Of the 189, or 84% who reported

6The nature of these modifications was questioned during the interviews conducted and is discussed in that section of this dissertation.
no use of decision tables (Table 8) 184, or 81% reported a reason as shown in Table 10. Of the 81%; 154, or 68% reported "no opportunity to use," 2, or 1% reported that they were "requested or directed not to use the technique," and 28, or 12% reported "other."

TABLE 10
DECISION TABLE LIMITING FACTORS

<table>
<thead>
<tr>
<th>Factors</th>
<th>#</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>No opportunity to use</td>
<td>154</td>
<td>68</td>
</tr>
<tr>
<td>Requested or directed not to use</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Other</td>
<td>28</td>
<td>12</td>
</tr>
<tr>
<td>TOTAL</td>
<td>184</td>
<td>81</td>
</tr>
</tbody>
</table>

Value of the education - questions 25 and 26

These two questions were designed to measure the value of the education given to the students. To generate a range of answers, structured multiple choice questions that required a "much," "some," "little," or "none" answer were used. Question 25 probed the value of five specific subjects presented to the students in the course. Question 26 surveyed the impact of the course on more specific personal skills of each respondent.

Course subjects - question 25

The first three subjects listed in Table 11 were taught to the students as concepts in the theory of management information systems. The last two subjects listed as flow charting and grid charting were taught as techniques. Flow charting, briefly mentioned in this
dissertation, was included in this question because it has been a traditional technique of the analyst and the computer programmer and it would provide for a relative comparison to grid charting.

**TABLE 11**

VALUE OF FIVE COURSE SUBJECTS

Question 25 - Of what value have the following phases of your systems training at the School of Systems and Logistics been in your professional work?

<table>
<thead>
<tr>
<th>Subject</th>
<th>Blank</th>
<th>Much</th>
<th>Some</th>
<th>Little</th>
<th>None</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>Defining systems</td>
<td>3 1</td>
<td>65 29</td>
<td>107 47</td>
<td>28 12</td>
<td>23 10</td>
</tr>
<tr>
<td>Establishing boundaries</td>
<td>4 2</td>
<td>52 23</td>
<td>100 44</td>
<td>39 17</td>
<td>31 14</td>
</tr>
<tr>
<td>Spillover effects</td>
<td>10 4</td>
<td>16 7</td>
<td>74 33</td>
<td>61 27</td>
<td>65 29</td>
</tr>
<tr>
<td>Flow charting</td>
<td>4 2</td>
<td>41 18</td>
<td>92 41</td>
<td>51 23</td>
<td>38 17</td>
</tr>
<tr>
<td>Grid charting</td>
<td>5 2</td>
<td>18 8</td>
<td>65 29</td>
<td>45 20</td>
<td>93 41</td>
</tr>
<tr>
<td>AVERAGE</td>
<td>2%</td>
<td>17%</td>
<td>39%</td>
<td>20%</td>
<td>22%</td>
</tr>
</tbody>
</table>

The maximum positive responses for the first four subjects were tallied in the "Some" category as shown in Table 11. The answer distribution for the five subjects ranged from a high of 107, or 47% for "defining systems," to a low of 65, or 29% for "grid charting," with an arithmetic mean of 49%. The responses for "grid charting" tallied 18, or 8% for the "Much" category, 65, or 29% for the "Some" category, 45, or 20% for the "Little" category, and 93, or 41% for the "None" category. The responses for "flow charting" tallied 41, or 18% for the "Much" category, 92, or 41% for the "Some" category, 51, or 23% for the "Little" category and 38, or 17% for the "None" category.

^See Chapter I, pp. 4, 5, and 9.
Personal skills - question 26

As shown in Table 12, the majority of the respondents checked the "Some" category for five of the six personal skills. The majority checked the "Much" category for the "broader concept of systems" listed as the second item in Table 12. The answer distribution in the "Some" category ranged from a high of 122, or 54% for "professional skills," to a low of 87, or 38% for the "broader concept of systems," with an arithmetic mean of 49%.

TABLE 12
IMPACT ON PERSONAL SKILLS

<table>
<thead>
<tr>
<th>Skills</th>
<th>Blank</th>
<th>Much</th>
<th>Some</th>
<th>Little</th>
<th>None</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>#</td>
<td>%</td>
<td>#</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>Professional skills</td>
<td>4</td>
<td>2</td>
<td>45</td>
<td>20</td>
<td>122</td>
</tr>
<tr>
<td>Broader concept of systems</td>
<td>1</td>
<td>0</td>
<td>108</td>
<td>48</td>
<td>87</td>
</tr>
<tr>
<td>Independent thinking</td>
<td>2</td>
<td>1</td>
<td>36</td>
<td>16</td>
<td>113</td>
</tr>
<tr>
<td>Personal growth</td>
<td>2</td>
<td>1</td>
<td>43</td>
<td>19</td>
<td>121</td>
</tr>
<tr>
<td>Liberal point of view</td>
<td>2</td>
<td>1</td>
<td>60</td>
<td>27</td>
<td>99</td>
</tr>
<tr>
<td>Think in larger systems</td>
<td>1</td>
<td>0</td>
<td>59</td>
<td>26</td>
<td>121</td>
</tr>
<tr>
<td>AVERAGE</td>
<td>1</td>
<td>26%</td>
<td>49%</td>
<td>17%</td>
<td>7%</td>
</tr>
</tbody>
</table>

Another interesting aspect of these data evolved by combining the "Much" and "Some" answers in Tables 11 and 12 for comparison to the "Yes" answers of basically the same questions in Tables 2 and 4, and by combining the "Little," "None," and "Blank" answers in Tables 11 and 12 for comparison to the sum of the "No," "Questionable," and "Blank" answers of basically the same questions in Tables 2 and 4. Such combinations of answers to the various related questions are shown in Table 13. The answer distributions for the questions on the "usefulness
of grid charts" in Tables 3 and 5 were also included. The answer distributions for the informative value of the lecture on "defining boundaries" and the educational value of "defining systems," which are the same basic concepts, came within 1% of each other. Although the students felt that their education had contributed to a "broader concept of systems" and to "thinking in terms of larger systems" in their professional work, they rated the value of "establishing boundaries in their professional work" 10% lower than the value of the lecture. This tends to indicate that the scope of any system is being rigidly fixed before a systems study is assigned.

<table>
<thead>
<tr>
<th>Subject</th>
<th>Table #</th>
<th>Much + Some or Yes</th>
<th>Little+None+Blank or No+Question+Blank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Defining systems</td>
<td>11</td>
<td>172 76%</td>
<td>54 25%</td>
</tr>
<tr>
<td>Defining boundaries</td>
<td>2</td>
<td>175 77%</td>
<td>52 23%</td>
</tr>
<tr>
<td>Broader concept of systems</td>
<td>12</td>
<td>195 86%</td>
<td>31 13%</td>
</tr>
<tr>
<td>Think in larger systems</td>
<td>12</td>
<td>180 80%</td>
<td>46 20%</td>
</tr>
<tr>
<td>Establishing boundaries</td>
<td>11</td>
<td>152 67%</td>
<td>74 33%</td>
</tr>
<tr>
<td>Spillovers or side effects</td>
<td>2</td>
<td>141 62%</td>
<td>85 37%</td>
</tr>
<tr>
<td>Spillovers or side effects</td>
<td>11</td>
<td>90 40%</td>
<td>136 60%</td>
</tr>
<tr>
<td>Value of flow charting</td>
<td>11</td>
<td>133 59%</td>
<td>93 42%</td>
</tr>
<tr>
<td>Value of grid charting</td>
<td>11</td>
<td>83 37%</td>
<td>143 63%</td>
</tr>
<tr>
<td>Used grid charts</td>
<td>4</td>
<td>73 31%</td>
<td></td>
</tr>
<tr>
<td>Not used grid charts</td>
<td>4</td>
<td></td>
<td>153 68%</td>
</tr>
<tr>
<td>Grid charts useful</td>
<td>3</td>
<td>107 47%</td>
<td>119 53%</td>
</tr>
<tr>
<td>Grid charts useful</td>
<td>5</td>
<td>58 26%</td>
<td>168 75%</td>
</tr>
</tbody>
</table>

This deduction also tends to be more strongly confirmed in the answers to the informative value of the lecture and to the value in use of the "spillover or side effects" concept. The lecture rated affirmatively 22% higher than the value in use. These data showed an inverse relationship between the informative values of 62% affirmative
and 37% negative to the educational values of 40% affirmative and 60% negative. Since the concept of side effects on other systems is directly dependent upon the boundary or systems definition, the lower educational value more strongly confirms the deduction that systems boundaries are rigidly fixed before the study is assigned.

Another inverse relationship appeared between the educational values of flow charting and grid charting. Although flow charting has been a traditional technique, it is interesting to note that the educational value of grid charting and the value in the use of grid charting were within 5%-6% of each other. These data tend to indicate that one group used grid charts and the other students used traditional flow charts.

Although 107, or 47% of the 226 respondents, said grid charts were "useful," only 73, or 31% identified any actual use. Of this latter group; 58, or 26% said that grid charts were "useful." There were 49 students, or 21% who felt they were "useful" but had "no opportunity to use" them.

The analysis continued into a breakdown of the data by the seven coded job titles described in Question 3 of the questionnaire. These distributions are discussed in the next section.

Questionnaire Analysis by Job Code

In this phase, the questionnaire data were sorted into the seven job titles listed in Question 3 of the questionnaire. The respondents' answers to each question were tabulated by number and percentage within each job title. A second sort of the data regrouped the answers by job title within each question. The results were divided into the four
categories of Concepts, Grid Charts, Decision Logic Tables, and Value of the Education. The 226 students responding to the questionnaire were distributed among the seven job titles as shown in Table 14.

**TABLE 14**

**JOB TITLE DISTRIBUTION**

<table>
<thead>
<tr>
<th>Code No.</th>
<th>Title</th>
<th>Count</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Systems Analyst</td>
<td>86</td>
<td>38</td>
</tr>
<tr>
<td>2</td>
<td>Systems Specialist</td>
<td>26</td>
<td>12</td>
</tr>
<tr>
<td>3</td>
<td>Supervisory Systems Analyst</td>
<td>23</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>Programmer</td>
<td>20</td>
<td>9</td>
</tr>
<tr>
<td>5</td>
<td>Lead Programmer</td>
<td>10</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>User or Purchaser</td>
<td>31</td>
<td>14</td>
</tr>
<tr>
<td>7</td>
<td>Other</td>
<td>30</td>
<td>13</td>
</tr>
<tr>
<td>99</td>
<td>Summary</td>
<td>226</td>
<td>100%</td>
</tr>
</tbody>
</table>

Although the systems analyst, Job Code 1, and the systems specialist, Job Code 2, are listed separately in the table, they essentially accomplish the same function. The intended difference⁸ was that the specialist is the individual who remains with the same system, knows the entire system, and evaluates requested changes to the system; and the analyst implements changes and remains with a system only for the implementation of those changes. The lead programmer, Job Code 5, supervises one or more programmers, Job Code 4. The users or purchasers, Job Code 6, are the recipients of final reports from the information system. The other, Job Code 7, category was included for

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⁸Intended difference is used because the interview phase of the research disclosed many variations of this combination.
those individuals who felt they were not direct users even though their functional area did receive final reports from an information system.

Concepts - questions 13-15

Optner concepts - questions 13 and 14

The data in Table 15 indicate that 70% of the lead programmers, Job Code 5, found "Optner's module useful in their work." Also, Optner's classification of systems provided more insights to problem areas in systems for 65% of the programmers, Job Code 4, and 65% of the users, Job Code 6.

TABLE 15

<table>
<thead>
<tr>
<th>JOB CODE</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>S. COUNT</strong></td>
<td>86</td>
<td>26</td>
<td>23</td>
<td>20</td>
<td>10</td>
<td>31</td>
<td>30</td>
<td>226</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Q U E S T I O N</th>
<th><strong>JOB CODE</strong></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th><strong>TOTAL</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>13 Optner's Module</td>
<td>63 65 65 60 70 42 67 61</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14 Optner's Classification</td>
<td>57 54 39 65* 30 65* 43 54</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15-1 Lack of Theory</td>
<td>70* 54 70* 65 40 58 43 61</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15-2 Lack of Standard Definition</td>
<td>83 65 91* 90 70 77 53 77</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15-3 Spillovers</td>
<td>67 50 70* 70* 60 58 53 61</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15-4 Defining the Boundaries</td>
<td>79 62 87* 80 70 87* 70 77</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15-5 Internal Balance</td>
<td>56 46 57 55 50 71* 53 56</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15-6 External Balance</td>
<td>56 46 52 55 50 71* 50 56</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15-7 Computer Complex</td>
<td>64 50 61 60 60 74* 60 62</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15-8 Systems Criteria</td>
<td>88 65 78 90* 70 77 77 81</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| **Average Percentage** | 68 56 67 69* 57 68 57 65 |

*Largest row percentage

Systems concepts - question 15

By using the greatest percentage value in each row of Table 15 as a measure to identify those job codes that derived the greatest...
informational values from the concepts, the data revealed two such job codes: the supervisory analysts, Job Code 3, and the users, Job Code 6. The supervisory analysts found the first four concepts, specifically the "lack of theory" (70%), "lack of standard definitions" (91%), "spillover or side effects" (70%), and "defining the boundaries" (87%) as the most informative concepts for their group. The users found that "defining the boundaries" (87%), "internal balance of capacity" (71%), and the "computer complex" (74%) were the most informative concepts of their group.

The three highest percentage values in Table 15 were: 91% of the Supervisory Analysts believed the topic "lack of standard definition" was valuable, and 90% of the Programmers believed the topics "lack of standard definitions" and "systems criteria" as a management responsibility were valuable.

**Grid charts - questions 18-21**

The affirmative answers by job code to Questions 18, 20-2, and 20-6 were grouped in Table 16 to facilitate a comparative analysis. Question 18 dealt with the values of grid charting prior to indicating use of grid charts, and Question 20 dealt with the values and areas of use of grid charting if grid charts had been used. As shown in Table 16, the answer percentages to Question 18 were from 28% to 30% larger in range than the answer percentage values to Question 20-5.

Although grid charting is basically a tool of the systems analyst, these data show that the lead programmers, Job Code 5, valued grid charting more highly than the systems analysts, Job Code 1, and surpassed them in the areas of use.
<table>
<thead>
<tr>
<th>JOB CODE</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>COUNT</td>
<td>86</td>
<td>26</td>
<td>23</td>
<td>20</td>
<td>10</td>
<td>31</td>
<td>30</td>
<td>226</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Yes Answers in Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interesting</td>
</tr>
<tr>
<td>18-1</td>
</tr>
<tr>
<td>18-2</td>
</tr>
<tr>
<td>18-3</td>
</tr>
<tr>
<td>AVERAGE</td>
</tr>
<tr>
<td>Facilitate analysis</td>
</tr>
<tr>
<td>20-2-1</td>
</tr>
<tr>
<td>20-6-1</td>
</tr>
<tr>
<td>Related mgt. functions</td>
</tr>
<tr>
<td>Data elements</td>
</tr>
<tr>
<td>AVERAGE</td>
</tr>
</tbody>
</table>

Table 17 shows that the systems analysts reported the largest amount of grid chart use. However, normalizing of the data, by assuming that a more-than-five-time use was a six-time use and dividing the total number of grid chart applications within each job code by the numerical count of respondents within that job code, showed that the lead programmers reported more applications per person than the systems analysts. Although this process tends to more favorably weight the values of the lead programmers' answers, due to their small number and high usage, any other weighting process also would distort the values because the entire population was surveyed and percentages do provide a basis for comparison.
Analysis of the "Logistics Functions involved" in the data systems grid charted by the job code categories in Table 18 showed that the systems analysts encountered more functions in their grid chart applications than the lead programmers. However, the lead programmers averaged better than one function per lead programmer while the systems analysts averaged two functions for every three analysts.
For the 47 DSAP's reported in which grid charts were used, Table 19 shows their distribution among the seven job codes. Numerically, the Systems Analysts encountered more DSAPS than the Lead Programmers. However, on a unit basis, the lead programmers encountered .7 DSAPS per person and the systems analysts encountered only .3 DSAPS per person.

**TABLE 19**

**DSAP DISTRIBUTION - QUESTION 20-1**

<table>
<thead>
<tr>
<th>JOB CODE</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>COUNT</td>
<td>86</td>
<td>26</td>
<td>23</td>
<td>20</td>
<td>10</td>
<td>31</td>
<td>30</td>
<td>226</td>
</tr>
<tr>
<td>DSAPS - No.</td>
<td>26</td>
<td>7</td>
<td>3</td>
<td>3</td>
<td>7</td>
<td>1</td>
<td>0</td>
<td>47</td>
</tr>
</tbody>
</table>

The job code distribution of the factors limiting the use of grid charts from the answers to Question 21 are shown in Table 20. The majority of the nonusers in each job code answered "no opportunity to use" grid charts. Two systems analysts reported that they were "requested or directed not to use" grid charts. Most revealing is the fact that 43, or 50% of the Systems Analysts, and 12, or 46% of the Systems
Specialists, reported "no opportunity to use" as their reason for not using grid charts and this was investigated in the interviews.

**Decision logic tables - questions 22-24**

For the analysis of the amount of decision table use by job code, the answers to Question 22 of the questionnaire were structured into Table 21. This table indicates that the systems analyst, Job Code 1, reported the greatest amount of decision table use. The total number of decision table applications was derived by assuming that a more-than-five-time use was a six-time use. Normalizing of these data by dividing the total number of applications within each job code by the number of respondents within that job code showed that the lead programmers reported more applications per person with 1.7 applications per lead programmer as compared to the systems analysts with 0.7 applications per analyst.

In regard to the value of decision logic tables, the affirmative answers to Question 23 were structured into Table 22. Although decision
Tables were taught as a technique for the systems analyst to establish management needs by relating conditions to actions, it was also stated that decision logic format was extremely familiar to programmers. Programmers have used analytical tables to convert arguments into precise functional values since the earliest computer development. The data in Table 22 show that lead programmers, Job Code 5, valued decision tables much more than the systems analysts, Job Code 1. The lead programmers' answer values averaged 48% and the systems analysts' answer values averaged only 18%.

### TABLE 22

VALUES OF DECISION TABLES - QUESTION 23

<table>
<thead>
<tr>
<th>JOB CODE</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>COUNT</td>
<td>86</td>
<td>26</td>
<td>23</td>
<td>20</td>
<td>10</td>
<td>31</td>
<td>30</td>
<td>226</td>
</tr>
</tbody>
</table>

Yes Answers in Percentage

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facilitate analysis</td>
<td>20</td>
<td>12</td>
<td>9</td>
<td>5</td>
<td>5</td>
<td>50*</td>
<td>13</td>
<td>3</td>
</tr>
<tr>
<td>Facilitate design</td>
<td>15</td>
<td>15</td>
<td>4</td>
<td>5</td>
<td>50*</td>
<td>10</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>Necessary to modify</td>
<td>12</td>
<td>8</td>
<td>4</td>
<td>0</td>
<td>40*</td>
<td>3</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>Useful</td>
<td>22</td>
<td>15</td>
<td>13</td>
<td>5</td>
<td>50*</td>
<td>10</td>
<td>3</td>
<td>16</td>
</tr>
<tr>
<td>Worth the effort</td>
<td>21</td>
<td>11</td>
<td>4</td>
<td>5</td>
<td>50*</td>
<td>13</td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>AVERAGE</td>
<td>18</td>
<td>12</td>
<td>7</td>
<td>4</td>
<td>48*</td>
<td>10</td>
<td>2</td>
<td>13%</td>
</tr>
</tbody>
</table>

*Largest row percentage

The distribution of answers to Question 24, which dealt with the factors limiting the use of decision tables, are shown in Table 23. The majority of the nonusers of decision logic tables within each job-code answered "no opportunity to use" decision logic tables. Two systems analysts reported that they were "requested not to use decision logic tables." More important is the fact that 63%, or 54 of the Systems Analysts, Job Code 1, 77%, or 20 of the Systems Specialists, Job Code 2,

---

9See Chapter IV, p. 87.
and 85%, or 17 of the Programmers, Job Code 4, all reported "no opportunity to use" as their reason for not using decision logic tables. Yet, the job codes that would have the greatest potential for the use of decision logic tables are these same three jobs; this incongruity was investigated in the interviews. As expected, the lead programmers were in the minority on the factors limiting the use of decision tables.

TABLE 23
DECISION TABLE LIMITING FACTORS - QUESTION 24

<table>
<thead>
<tr>
<th>JOB CODE</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>COUNT</td>
<td>86</td>
<td>26</td>
<td>23</td>
<td>20</td>
<td>10</td>
<td>31</td>
<td>30</td>
<td>226</td>
</tr>
<tr>
<td>No opportunity to use</td>
<td>#</td>
<td>54</td>
<td>20</td>
<td>14</td>
<td>17</td>
<td>2</td>
<td>23</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>63</td>
<td>77</td>
<td>61</td>
<td>85</td>
<td>20</td>
<td>74</td>
<td>80</td>
</tr>
<tr>
<td>Requested not to use</td>
<td>#</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td>Other</td>
<td>#</td>
<td>12</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>14</td>
<td>8</td>
<td>13</td>
<td>5</td>
<td>10</td>
<td>17</td>
<td>12</td>
</tr>
<tr>
<td>TOTAL</td>
<td>#</td>
<td>68</td>
<td>22</td>
<td>17</td>
<td>18</td>
<td>4</td>
<td>26</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>79</td>
<td>85</td>
<td>74</td>
<td>90</td>
<td>40</td>
<td>84</td>
<td>97</td>
</tr>
</tbody>
</table>

Value of the education - questions 25 and 26

These two questions probed the value of five specific subjects presented to the students in the course and the impact of the course on more specific personal skills of each respondent.

Course subjects - question 25

The individual percentages of the answers in the "much" and "some" categories of Question 25 were structured into Table 24. Although the majority of the respondents' answers were in the "some" category, 43% of the supervisory analysts, Job Code 3, rated the value of both the concepts of "defining systems" and "establishing boundaries" under the "much" category. For the same concepts, approximately 28% of the
systems analysts, Job Code 1, rated the value of the concepts in the "much" category. These two concepts as subjects ranked the highest in the "much" category of answers. The "spillover effects" concept ranked fourth in the "much" answer category. On the average, "much" value was gained by a greater percentage of the supervisory analysts, Job Code 3, than any other job code.

As the maximum values in the "some" category, 57% of the systems analysts, Job Code 1, felt that the concept of "defining systems" was of value. For the same concept, 50% of the lead programmers agreed with the systems analysts. For the concept of "establishing boundaries," the maximum value was set by 54% of the systems specialists, Job Code 2. "Spillover effects" were the most important in value to 50% of the programmers, Job Code 5. "Flow charting" was valued by 62% of the systems specialists, Job Code 2, and "grid charting" was valued by 40% of the lead programmers, Job Code 5. On the average, "some" value was gained by a greater percentage of the systems specialists, Job Code 2, than any other job code. In each of the "much" and "some" answer categories, the systems analysts, Job Code 1, placed second in ranking of the job codes on a percentage base.

Although the percentage values were increased by combining the "much" and "some" answers as shown in the bottom third of Table 24, all of the job code maximum value relationships established in the "some" category remained the same except for one. That one exception was the shift in "establishing boundaries" from the systems specialist, Job Code 2, to the systems supervisor, Job Code 3. On the average, value was gained in percentage order by 65% of the systems specialists, 62% of the systems analysts, 54% of the systems supervisors, 54% of the
programmers, 52% of the lead programmers, 48% of the users, and 43% of the others from the five course subjects.

TABLE 24
VALUE OF FIVE COURSE SUBJECTS

<table>
<thead>
<tr>
<th>Ques.</th>
<th>JOB CODE</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Count</td>
<td></td>
<td>86</td>
<td>26</td>
<td>23</td>
<td>20</td>
<td>10</td>
<td>31</td>
<td>30</td>
<td>226</td>
</tr>
<tr>
<td>25-1</td>
<td>Defining Systems</td>
<td>28</td>
<td>31</td>
<td>43*</td>
<td>30</td>
<td>30</td>
<td>29</td>
<td>17</td>
<td>29</td>
</tr>
<tr>
<td>2</td>
<td>Establishing Boundaries</td>
<td>29</td>
<td>19</td>
<td>43*</td>
<td>25</td>
<td>10</td>
<td>13</td>
<td>7</td>
<td>23</td>
</tr>
<tr>
<td>3</td>
<td>Spillover Effects</td>
<td>10*</td>
<td>8</td>
<td>9</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
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"SOME" ANSWERS IN PERCENT

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"MUCH + SOME" ANSWERS IN PERCENT

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<td>48</td>
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*Largest row percentage

The individual percentages of the answers in the "much" and "some" categories of Question 26 were structured into Table 25. Although the majority of the respondents' answers appeared to be in the "some" category, four of the job codes had maximum values of 50% or greater in the "much" category. Specifically, 55% of the programmers, 50% of the lead programmers, 58% of the users, and 53% of the others felt that the course contributed "much" to their "broader concept of systems." The four minimum values in the "much" category were 0% of the lead
programmers and 8% of the systems specialists for "professional skills."
The averages of the "much" category values showed that a greater percentage of the programmers, Job Code 4, the others, Job Code 7, the systems supervisors, Job Code 3, and the users, Job Code 6, felt that the education had an "impact on personal skills."

In the "some" category, the systems specialists, Job Code 2, were in the majority in five of the six "personal skills" as shown in the center section of Table 25. These were 73% for "professional skills," 50% for a "broader concept of systems," 62% for "independent thinking," 62% for a "more liberal point of view," and 62% for the "ability to project thinking into larger systems." The one remaining personal skill, with a majority shown by 70% of the lead programmers, Job Code 5, was "personal growth." From these distributions, it is obvious that a greater percentage of the systems specialists, Job Code 2, felt the education contributed to their "personal skills" than did the other job codes, as shown in Table 25.

In the combination of the "much" and "some" values shown in the bottom third of Table 25, the users, Job Code 6, were in the majority in five of the six "personal skills." These were 93% for the "broader concept of systems," 77% for "independent thinking," 84% for "personal growth," 77% for a "more liberal point of view," and 90% for the "ability to project thinking into larger systems." The systems supervisors, Job Code 3, were in the majority when 83% indicated that the course contributed to their "professional skills." On the average, 81% of the users, 78% of the others, 77% of the systems specialists, 74% of the systems analysts, 73% of the systems supervisors, 70% of the
programmers, and 67% of the lead programmers felt that the course contributed to their personal skills.

### TABLE 23

**IMPACT ON PERSONAL SKILLS**

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<td>Broader Concept of Systems</td>
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<td>4</td>
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<tr>
<td>Personal Growth</td>
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<td>28</td>
<td>15</td>
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<td>Think in Larger Systems</td>
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<td>62*</td>
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<td>Liberal Point of View</td>
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<td>Think in Larger Systems</td>
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<td>AVERAGE</td>
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</table>

**Consistency Check of the Questionnaire**

Although it is sometimes impractical to apply statistical measures to facts . . . , data can always be scrutinized for accuracy and logic. In an attempt to measure the consistency of the respondents' answers to the questionnaire, certain questions pertaining to the same

subject were scattered through the questionnaire. The answers to these questions were arrayed in two-dimensional matrices to compare the consistency of the answers. Such matrices shall be referred to as validity arrays.

Using the IBM 1620 computer, a set of validity arrays was made for the 226 respondents in order to compare the consistency of their answers to those questions dealing with the concepts. A second set of arrays was made for the 73 respondents who had used grid charts, to compare the consistency of their answers to the questions dealing with grid charting.

Consistency Check of the Concepts

Spillover effects - questions 15-3 and 25-3

Although 141, or 62% of the students, said the "lecture was enlightening," only 77, or 55% felt that the concept had been of "much" and "some" value in their work (Table 26). Since the interviews revealed that the scope of activity of the analysts was limited\(^\text{11}\) and the specialists reported a lack of enough qualified people,\(^\text{12}\) this array shows that the effect of these two limiting factors was to restrict the use of the "spillover concept." Yet, one of the greatest problem areas cited by the supervisors in their interviews was in the interrelationships between systems.

Boundaries - questions 15-4 and 25-2

Although 175, or 77% of the students, said the lecture was enlightening, only 129, or 74% felt that the concept had been of "much"

\(^{11}\text{Infra, p. 137.} \quad ^{12}\text{Infra, p. 138.}\)
### TABLE 26

**CONCEPT VALIDITY ARRAYS**

#### SPILLOVER EFFECTS

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<thead>
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#### DEFINING BOUNDARIES

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#### OPTNER’S MODULE - DEFINING SYSTEMS

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#### OPTNER’S CLASSIFICATIONS - DEFINING SYSTEMS

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<td>226</td>
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</table>
and "some" value in their work. Even though the activity of the analysts may be restricted, this does not affect the use of this concept, which accounts for the larger numbers. The concept of "defining the boundaries" of a system and its use are not related to the scope of activity or the span of operation of systems effort.

Optner's module and defining systems - questions 13 and 25-1

Although 138, or 61% of the students, felt that Optner's module had been useful in their work, 115, or 83% of these students, reported that the concept of "defining systems" had been of "much" and "some" value in their professional work. Optner's module is one important segment of the concept of defining a system.

Optner's classifications and defining systems - questions 14 and 25-1

Of the 121, or 54% of the students, that felt that "Optner's classification of systems as structured and unstructured provided some insights to the problem areas in systems," 102, or 84% of these students reported that the concept of "defining systems" had been of "much and some" value in their professional work. Optner's classification is another important segment of the concept of defining a system.

Consistency Check of the Grid Charting Questions

Grid chart value in use - questions 18-2 and 20-4-1

Of the 73 students who reported use of the grid charting technique, 53, or 73% of these students, said that the "technique was useful as a tool for representation of the system" in answer to Question 18-2.
Later on, 51, or 96.2% of the 53 students, or 70% of the original 73 students who reported grid chart use, were consistent in their opinions that the technique was useful (Table 27). Since 58 students said the technique was useful, seven students must have used grid charts for applications other than system representation.

**Grid chart value in effort - questions**

18-3 and 20-4-2

Of the 73 students who reported use of the grid charting technique, 64, or 88% of these students, agreed that the time devoted to learning the technique was "time well spent." Also, 51 of these 64 students, or 70% of the 73 students, considered that their application of the technique was "worth the effort." Thus, there were 13 students who felt that learning the technique was "time well spent" but not "worth the effort."

**Grid chart value in work - questions**

18-2 and 25-5

Of the 53 students who said the grid charting technique was useful as a "tool for representation of the system," 48 reported that grid charting had been of "much" and "some" value in their professional work. Thus five students felt that the "technique was useful" and also felt it had been of "little" and "questionable" value in their professional work.

**Grid chart value in work - questions**

20-4-1 and 25-5

Of the 58 students who said the "technique was useful," 51 felt that the technique had been of "much" and "some" value in their work,
TABLE 27

GRID CHART VALIDITY ARRAYS

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<td>11</td>
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<td>0</td>
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<td>11</td>
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<td>0</td>
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<th>Answers</th>
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<tr>
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<td>11</td>
<td>35</td>
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<td>Ques.</td>
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<td>3</td>
<td>4</td>
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<td>2</td>
<td>12</td>
<td>46</td>
<td>12</td>
<td>1</td>
<td>73</td>
</tr>
</tbody>
</table>
thus seven students who felt that the "technique was useful" also felt that it had been of "little" and "questionable" value in their professional work.

**Grid chart value in work - questions 18-3 and 25-5**

Of the 64 students who said that grid charting was "time well spent," 54 felt that grid charting had been of "much" and "some" value in their work. Thus, 10 students who said that grid charting was "time well spent" felt that grid charting had been of "little" and "questionable" value in their professional work.

**Grid chart value in work - questions 20-4-2 and 25-5**

Of the 52 students who said that grid charting was "worth the effort," 46 felt that grid charting had been of "much" plus "some" value in their professional work. Thus, six students who said that grid charting was "worth the effort" felt that grid charting had been of "little" and "questionable" value in their professional work.

**Analysis of the Interview Data**

The original intent of this research phase was to interview only those students who had used grid charts and decision tables to probe their applications more deeply. As the questionnaire data were being analyzed, it was decided to interview students who had not used grid charts and decision tables to probe the reasons for their nonuse more deeply than could be discerned from the questionnaire.

Therefore, a purposive, stratified, random sample of 60 names was selected from the 226 respondents to the questionnaire. The sample was
to contain 30 users and 30 nonusers of grid charts from all seven job codes and a table of random numbers was used for sample selection. Of the sample of 60, 50 students were located and interviewed. The remaining 10 were absent due to sickness, vacation, or traveling on business. The pertinent distribution characteristics of the interview sample and the related questionnaire population are shown in Table 28 and in Appendix F. The 29 interviewers who used grid charts accounted

<table>
<thead>
<tr>
<th>TABLE 28</th>
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<tbody>
<tr>
<td>DISTRIBUTION CHARACTERISTICS OF THE INTERVIEW</td>
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<table>
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<tr>
<th>TITLE</th>
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<th>Sample</th>
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<tr>
<td>Grid Charts Used Not Used Total</td>
<td>Grid Charts Used Not Used Total</td>
<td>Grid Charts Used Not Used Total</td>
<td></td>
</tr>
<tr>
<td>1 Analysts</td>
<td>35 51 86</td>
<td>8 3 11</td>
<td>23% 6% 13%</td>
</tr>
<tr>
<td>2 Speci.</td>
<td>9 17 26</td>
<td>4 1 5</td>
<td>44 6 19</td>
</tr>
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<td>3 Supvr.</td>
<td>4 19 23</td>
<td>4 9 13</td>
<td>100 42 57</td>
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<td>4 Prog.</td>
<td>3 17 20</td>
<td>3 2 5</td>
<td>100 12 25</td>
</tr>
<tr>
<td>5 Ld.Prog.</td>
<td>8 2 10</td>
<td>5 1 6</td>
<td>63 50 60</td>
</tr>
<tr>
<td>6 Users</td>
<td>7 24 31</td>
<td>2 2 4</td>
<td>29 8 13</td>
</tr>
<tr>
<td>7 Others</td>
<td>7 23 30</td>
<td>3 3 6</td>
<td>43 13 20</td>
</tr>
<tr>
<td>TOTAL</td>
<td>73 153 226</td>
<td>29 21 50</td>
<td>40% 14% 22%</td>
</tr>
</tbody>
</table>

NOTE: Sample to population in percentage.

for 113 of the 234 grid chart applications in 31 of the 47 DSAP systems. Of the 29, nine accounted for 31 of the 109 decision logic table applications reported by 38 of the respondents. Each interview was directed carefully by starting with two-way questions and ultimately proceeding to directed free-answer questions. For example, each student who had indicated his use of grid charts in the questionnaire was asked:

1. Did you use grid charts?
2. How many times?
3. How many grid charts did you construct?
4. What DSAP or data system was involved?
5. How many months were used for analysis and design?
6. How many analysts, programmers, etc. were used?
7. What were the logistics functions involved?
8. What grid chart factors did you display in your grid charts?
9. What is your reaction to grid charts, just from using them?
10. What results did you encounter?

The same basic pattern was repeated in the questions on decision tables. Then all interviewees were asked for any general comments about the course. At this point, the need for any additional questions was determined by the nature of the respondent's answers. The interview served not only to probe for more detailed information but also to validate the questionnaire data.

The data gathered during these interviews were grouped by the seven job categories used in the questionnaire and will be presented in that sequence. No further categorization of these data was attempted since complete anonymity of the interview data was guaranteed to the students to assure more truthful answers during each interview. Further categorizations would only destroy this trust.

The systems analysts - job code 1

Of the 11 analysts interviewed, eight analysts had used grid charts in 11 different information systems. Of the eight analysts who had used grid charts, three had used decision logic tables to evaluate data relationships. One of these analysts also had used decision logic tables to evaluate the factors used in forecasting requirements. The development time of these 11 systems ranged from three to 72 months and
involved from three to 32 people. The grid chart factors most frequently displayed were documents, reports, data elements, magnetic tape records, and magnetic tape files.

The analysts who had used grid charts generally agreed that flow charts were acceptable for small systems but they could not compete with grid charts in large systems. They tended to restrict their use of flow charts to the display of computer logic because flow charts became too complex and cumbersome when used to display large information systems. One analyst said he "completely eliminated his need for flow charts" by his use of grid charts and decision tables.

The advantages of grid charting cited by the analysts included "a rapid understanding of the system," "a permanent record," "the technique quickly revealed the behavior of each data element," "uncovered unnecessary and redundant data elements," "displayed data element and information trails," and "provided a capability to test system changes." For example: in the Consumption Requirements Computation System for IBM 7080 that required 32 people 12 months to design, one analyst reported the use of "three grid charts to analyze existing documents and data elements" and "three grid charts to design magnetic tape files." He also reported the use of "three decision logic tables to test for the redundancy of data elements in the design of final reports." His reaction to grid charts and decision logic tables was the "they provided a permanent record," "they provided a rapid understanding of the system," and "they readily disclosed the behavior of all data elements. His reaction to flow charts was that "they were cumbersome, limited in use, and couldn't compete with grid charts and decision
tables." He did report the use of a symbolic logic flow chart in the programming of the new system.

The reactions of other analysts working with other system designs were that "grid charts provided an analysis and design capability that flow charts lacked." They felt that "flow charts were acceptable for small systems and difficult to follow when used for large systems."

"Both grid charts and decision logic tables provided a permanent record of the system, readily displayed data element and information trails, and provided a capability to test systems changes."

"The use of grid charts facilitated the elimination of redundant and unnecessary data elements, facilitated the design of new tape files, and resulted in a more efficient system design." This analyst felt that "flow charts should be used only to portray the computer program logic."

One analyst reported that he "preferred flow charts to portray computer logic" because he had "extensive experience in their use" and he didn't want to "risk using something new like decision logic tables." However, he felt that "grid charts were superior to flow charts for analysis and design of the system because they revealed unnecessary elements of data."

Another analyst reported his use of grid charts and six decision logic tables to model a subsystem. His reaction was that his "model was extremely worthwhile, required no follow-up after changes were made, and eliminated the need for flow charts."

All of the analysts, who had indicated that it was necessary to modify their use of grid charts in the questionnaire, said during their interviews that the modification referred to their use of computer tape records and computer tape files rather than to documents in their grid
charts. They were interested in flows of information through existing automated information systems and they considered the display of computer tape records and files as modifications since only paper documents were used in teaching grid charting. This same reason was cited by all of the students who had indicated a need to modify their grid charts and their decision logic tables.

One of the analysts who had not used grid charting felt that it was hard to follow the flow of documents through the computer. Yet, every analyst who used the technique indicated that their use had included computer tape units, records, and/or files.

The limiting factors cited by the analysts were more general in nature such as "a misunderstanding of the purpose of the course," "analysts are not doing what they are supposed to do," "a lack of definition of the analyst's job," "too much stress on the computer unless one is a programmer or somehow above management control," the analyst is "restricted to a small area or function," the analyst is "not allowed to cross functional lines," and "there are too many administrative duties or special assignments." One major specific complaint of the analysts was being rushed for time to implement the system. The direct effect of this was not to risk something new but to fall back onto traditional techniques such as flow charting.

An interesting comment was proffered by an analyst who had not used grid charts. He said that "the course brought out things never seen in writing." Another analyst who had not used decision tables said that he never quite understood their use but would really like to use them.
The systems specialist - job code 2

Of the five specialists interviewed, four specialists had used grid charts in four different information systems. None of the five specialists interviewed has used decision logic tables. Their reasons were that they "didn't have time," their "work didn't require the use of such tables," and their "use of the tables was restricted by management." The development time of these four systems ranged from three to six months and involved from two to 10 people. The grid chart factors most frequently displayed were document flows and data element interrelationships or interfaces between systems.

No advantages or disadvantages of the grid charts were cited by the specialists. However, their general comments did reveal some interesting limiting factors. For example, "our fire-fighting type of work doesn't require or provide an opportunity to use grid charts," "there really aren't enough qualified people," and "the course content is all good but use of what is learned is restricted." Also, "the course was a good orientation but not too helpful since it covered how things should occur." "The usual system cycle is political in nature and one doesn't have time to use grid charts or interviews very often." One specialist said that although he is "supposed to know the entire system" to which he is assigned, in many areas "only the analysts know the entire system and the specialists lean heavily on the analysts in those areas."

In regard to modifications to the grid charts, the specialists, as did the analysts, referred to the display of computer tapes and automated data in their grid charts as modifications.
The supervisory analysts - job code 3

Of the 13 supervisors interviewed, four supervisors had used grid charts on three different information systems and on a unique work load schedule involving the directive and document coordination between information systems.

Of the four supervisors who had used grid charts, only one supervisor reported a one-time use of decision logic tables to analyze specific data runs through the computer. He indicated that the "tables facilitated the analysis of data and flow logic, and presented no difficulties in use."

The development time of the three information systems ranged from 12 to 24 months and involved 15 to 32 people. The grid chart modifications referred to the display of computer tape files as documents.

The advantages of grid charting cited by these supervisory analysts were the "ease of data element analysis and design," "the ease of displaying data and document relationships," and the "ability to include and trace the frequency of reports." They also said that "grid charts and flow charts complement each other since flow charts displayed data processes and grid charts displayed data element relationships."

Another supervisor reported that "decision tables were superior to symbolic flow charts for the analysis of flow logic." He added, "with the masses of data in our systems, it takes several months to discover deficiencies, even with flow charts."

The reason cited by eight of the nine supervisors for not using grid charts was because their time was devoted to administrative duties. The remaining or ninth supervisor said he was "too busy making piecemeal changes to keep a large-scale information system current."
The general comments made by the supervisors during the interviews revealed many interesting limiting factors. One supervisor commented that the "course provided general information that was good for the analyst but did not provide a specific organization-directed way of doing systems work." Another supervisor commented that "the authority or importance placed on the analyst's role in government was extremely restricted by government red tape." He cited the example of "taking a recommendation for system improvement to the functional people and having no other recourse or place to go if the functional people don't accept the recommendation." There is not only "lack of understanding on the part of the users but also open resistance." Full authority and "responsibility to cross functional lines has not been given to the systems analysts in the logistics command."

A third supervisor commented that "the course was not for the practicing analyst but only for people who want to know what they do." Yet, a fourth supervisor commented that "the course gave him new concepts, new terms, new techniques even though he could not use the techniques and that the new terms were not used in the logistics command. Although the course did provide a broad orientation or understanding, it did not really make one an analyst." This same supervisor then said "the grid charting technique can be used in some areas but not generally" and that he did "learn the concepts of the work." Three other supervisors said that the "course was a good refresher and that all lectures were good." An eighth supervisor with no previous systems experience said that "the course provided him with a good background and he felt that other supervisory personnel should attend the course."
The ninth supervisor stated that by the time he "attended the course," he had "six years of hard experience and knew all about what was taught in the course." The tenth supervisor presented a different attitude when he said that "how the analysts do their work is their business" but he "insists on going through each original system design and checking each system design for completeness." Yet he cited the problems of "how far does the analyst go and how far does the programmer expect the analyst to go in the system design." He also cited "the lack of standard formats, forms, procedures or ways of doing things, and stressed a need for the specific basic requirements of documentation, development test procedures, and simulation." He criticized the "lack of evaluation criteria for a service test of a developed system."

Another supervisor said that the course pointed up why he did what he did and several other things that he should have been doing. He cited a need for "more extensive use of grid charts and decision tables" but due to the press of time he always "reverted to flow charts." With the present mass of data inputs from so many sources, "even with system flow charts it takes several months to discover what is wrong. There is no real appreciation of the tradeoff between built in feedbacks and checks to correct and modify errors in systems." The last supervisor spoke of his "primary concern of the interrelationships between hardware management, status of machine operations, and meeting schedules." There appears to be "no planned approach in systems evidenced by the inconsistent directives received from top management." However, there is a "real need for more knowledge of how computers are being used today." These latter comments point up not only the lack of
documentation of each operational system but also an inability to identify subsystem or inter/intra system data interrelationships quickly.

The programmers - job code 4

Of the five programmers interviewed, three programmers had used grid charts in five different information systems. None of the programmers made use of decision logic tables. The reason cited by three of the five programmers was that they were "more used to flow logic charts and preferred to use them" as they were "usually pressed for time." The other two programmers reported that their programs "had not provided an opportunity for them to use decision logic tables." The development time of these five systems ranged from two to 12 months and involved three to 32 people. The grid chart factors most frequently displayed were documents and data elements relationships and computer tape layouts, records, and tape unit relationships. Modifications again referred to the latter factors.

Only one programmer reported that "grid charts facilitated the writing of computer programs by providing a ready reference for the data element content of each computer tape record." He preferred to "use flow logic charts rather than decision logic tables" because he was "usually rushed" and had "more experience with flow logic charts." The programmers did not cite any other specific advantages or disadvantages of grid charts. The limiting factor most generally cited was that "due to the rush of time" they "preferred flow logic charts" because they were "more experienced in their use." One of the programmers stated that "the techniques and examples taught in the
course were oriented to general problems and should have been more specifically oriented to the limited environment" in which they work.

The lead programmers - job code 5

Of the six lead programmers interviewed, five had used grid charts in eight different information systems. Of the five lead programmers who had used grid charts, two had used decision logic tables. The reason cited by the nonusers was that they were usually pressed for time and that they preferred to use flow logic charts. The development time of these eight systems ranged from three to 48 months and involved three to 150 people. The grid chart factors most frequently displayed were data elements, computer tape layouts, records, and computer runs. The modifications to the technique made by the lead programmers referred again to the display of computer tape layout and records in their charts. Their grid charts were used primarily to analyze data flows through the computer and to trace their computer program logic.

The advantages cited by the lead programmers for grid charts were that the charts "provided the ability to research data quickly," resulted in increased efficiency of file maintenance programs," "facilitated the identification of equivalent and redundant data elements," "clarified the input and output data relationships," "provided a roadmap to develop a new system," "facilitated the tracing of program logic," "portrayed the entire system with its details," and "provided a capability to test changes that was lacking in flow charts."

One lead programmer reported that he had used a decision logic table "to define all actions that had to be accomplished by the analysts to complete the required specifications for his programmers" in
one major system effort. He felt that "this application reduced the amount of coordination between the analysts and his programmers and provided an excellent work plan." Another lead programmer reported that by using decision logic tables, he was "able to separate a large file maintenance computer program into two extremely efficient runs." He extended the classification of data elements as "identification" and "quantitative" from his grid charts into six decision logic tables and separated his file maintenance into these two areas. He then programmed an identification data element file maintenance run to precede a quantitative data element file maintenance run. He also incorporated a "frequency-of-occurrence control" in the program to monitor those data elements that change too frequently. The long term benefit of his additional effort has been demonstrated in a greater efficiency of operation in this particular system. He stressed the "need to do thorough research of data and data elements with the attitude of designing the system right and designing one segment at a time."

No specific disadvantages were cited. The one lead programmer who had not used grid charts said he was "pressed for time and had no opportunity to use grid charts." His one and only positive comment was that "it was nice to know that other people had the same problems."

The users - job code 6

Of the four users interviewed, only two had used grid charts. The first application was for a small system proposal in which grid charts were used to display the documents, the data elements, the functions, and their system interrelationships. The second application was in a system under development in which grid charts were used to display
document flows to management activities. In both applications, the
interviewees cited no problems with their use of grid charts and seemed
pleased with their use.

Of the two users that reported grid chart applications, the second
user reported that he "used decision logic tables to relate reports to
management actions." He indicated that the "tables clarified the
information needs and eliminated some redundant and unnecessary infor­
mation requirements extracted from an existing system for the study."
The advantage of the tables in this application was that they made the
action-to-information relationships in the system understandable. No
additional advantages or disadvantages were stated.

The only limiting factor cited by both of the nonusers was that
they never took time to try the technique. Their main purpose in
attending the course was to acquire a good orientation and to develop
a broad outlook in systems. This was accomplished since all of them
indicated that they could recognize and understand any grid chart or
decision table encountered in their work.

The others - job code 7

None of the six persons interviewed in this job code category used
grid charts. Their reasons ranged from "no real opportunity to use grid
charts" to "no application for grid charts" in their work.

Decision logic tables were not used by this group. The only
reasons cited were either "no opportunity to use the tables" or their
"work did not provide or allow for their application."

All of the people in this group attended the course to gain a
better understanding of the capabilities, limitations, requirements, and
problems of management information systems design and development. In addition to satisfying these objectives, this entire group said they could "easily recognize and understand grid charts and decision tables" even though they had not personally used them.
CHAPTER VI

SUMMARY, FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

SUMMARY

The primary purpose of this study was to evaluate the grid charting technique as a model for the analysis and design of large-scale integrated management information systems as exemplified by the Air Force Logistics Command. Although electronic data processors have revolutionized management information systems, little progress has been made in the analysis and design techniques employed in systems effort; systems knowledge and design have been acquired by trial and error experimentation. The systems field lacks effective techniques for analysis as well as a theoretical base to aid such analysis. Since effective use of an analysis technique must rest on a sound theoretical base, the scope of this study included the development and evaluation of concepts in the theory of management information systems pertinent to the grid charting technique as well as the evaluation of the technique itself.

To accomplish the primary purpose of this study, the following specific objectives were established:

1. To develop and teach a theory of management information systems and the grid charting technique.

2. To measure the degree of usefulness of the theory of management information systems and the grid charting technique.
3. To identify the advantages and disadvantages of the grid charting technique.

4. To identify modifications made to the grid charting technique.

5. To identify factors limiting the use of the grid charting technique.

Scope and methodology of this study

The theory of management information systems and the grid charting technique, an a priori development, had been subjected to experimentation in small and medium-scale management information systems.

The establishment of the Directorate of Data Systems in the Air Force Logistics Command offered the opportunity to subject the theory and the grid charting technique to a test of results in large-scale management information systems. This study involved 307 employees, assigned to work in management information systems in the Air Force Logistics Command, who were taught the grid charting technique and the theory of management information systems in a series of 24 seminars. The data gathering techniques employed were a questionnaire, which produced 226, or 74%, returns, and personal interviews of 50 students, 29 of whom were users and 21 nonusers of the grid charting technique. All of the data gathered was enumerated quantitatively as it related to each of the study objectives. Analysis of the questionnaire data was facilitated by the use of a computer. Computer programs were designed to detect errors in data, to produce various data distributions, and to array data to measure the consistency of the respondents' answers.
Findings

The significant findings of this study are presented as they relate to the specific research objectives of this study.

Development of a theory and the technique

A Theory of Management Information Systems and the Grid Charting Technique were developed and presented to the 226 respondents as described in Chapters III and IV in this study.

Usefulness of the theory of management information systems

1. The theory of management information systems provided informational value and value in use to a majority of the respondents. The informational values ranged from 54% to 83% and 74% to 86%, while the values in use ranged from 40% to 76%.

2. The theory has provided informational value to a majority of the respondents in each job category. However, the programmers derived more informational value than the systems analysts.

3. The systems criteria concept was valued as the most informative concept by 183, or 83%, of the respondents and by all job categories except the supervisory analysts and the users.

4. The systems education has contributed to the technical knowledge of 56% of the students and to the personal skills of 75% of the students. The greatest contributions to technical knowledge were

1 Supra, p. 103, Table 2.  
2 Supra, p. 111, Table 12.  
3 Supra, p. 110, Table 11.  
4 Supra, p. 103, Table 2.  
5 Supra, p. 115, Table 15.  
6 Supra, p. 110, Table 11.  
7 Supra, p. 111, Table 12.
reported by the specialists, the analysts, the supervisory analysts, the programmers, and the lead programmers. The greatest contributions to personal skills were reported by the users and the others and not by the analysts and the specialists.

5. The validity arrays of the concepts questions tended to indicate that the boundary or scope of any system was rigidly fixed before the systems study was assigned.

Usefulness of the grid charting technique

1. Of the 226 respondents, 32%, or 73 students, reported at least 234 grid chart applications in 47 DSAP numbered systems.

2. Of the 32%, or 73 students reporting grid chart applications, 26%, or 58 students felt grid charts were useful, 23%, or 52 students felt they were worth the effort, 27%, or 61 students reported they facilitated analysis, and 15%, or 34 students reported they facilitated design.

3. The grid charting factors displayed were reported as reports and documents by 23%, or 53 students, reports and data elements by 23%, 53 students, and reports and management functions by 13%, or 29 students.

4. Of the 226 respondents, 16%, or 37 students reported at least 103 decision logic table applications.

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8Supra, p. 124, Table 24. 9Supra, p. 128, Table 25.
10Supra, p. 131, Table 26. 11Supra, p. 104, Table 4.
12Supra, p. 105, Table 5. 13Supra, p. 106, Table 6.
14Supra, p. 108, Table 8.
5. Of the 16%, or 37 students reporting decision table applications, 16%, or 37 felt decision tables were useful, 15%, or 33 felt they were worth the effort, 15%, or 33 reported they facilitated analysis, and 12%, or 27 reported they facilitated design.  

6. The lead programmers, on a percentage basis, valued grid charting and decision tables much more than did the systems analysts or the systems specialists. Also the lead programmers, on a unit basis, reported more grid chart and decision table applications than did the systems analysts or the systems specialists. A greater percentage of the lead programmers, also, felt that grid charts and decision logic tables facilitated analysis, facilitated design, were useful, and were worth the effort.

7. These data show that the lead programmer is in the domain of the systems analyst. Either the present corps of analysts lacks qualified people, or it is severely limited by management. Perhaps the lead programmer, trained to think creatively, abstractly, and logically, more readily identifies what is needed for information automation and tends to circumvent the analyst. This may be a strong indication that job titles, functions, and capabilities are mismatched.

8. In the consistency check of the answers to the questions

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15Supra, p. 108, Table 9. 16Supra, p. 117, Table 16.
17Supra, p. 121, Table 22. 18Supra, p. 118, Table 17.
19Supra, p. 121, Table 21. 20Supra, p. 117, Table 16.
21Supra, p. 121, Table 22.
dealing with grid charting and its usefulness, 51 of the 53 students, or 96.2% were consistent in their opinions that grid charting was useful.\(^\text{22}\) The limits around 96.2% within which one would expect to find the true population were computed as 91% to 100%,\(^\text{23}\) or from 48 to 53 students. All of the grid chart question arrays produced values within these limits except the last array. In that array, of the 52 students who said that grid charting was worth the effort, only 46 felt that the technique had been useful in their professional work. One explanation for this exception was cited during the interviews of the 21 students who had not used grid charts. The pressure of short time schedules and the cautious attitude of management tended to preclude use of grid charts and would result in less value to the students in their professional work.\(^\text{24}\)

**Advantages of the grid charting technique**

The 29 students interviewed who had used grid charts represented 40% of the 73 students who reported over 234 grid chart applications in 47 DSAP systems. This group accounted for over 113 grid chart applications in 31 DSAP systems. Of the 29, nine interviewees accounted for over 31 of the 109 decision logic table applications reported by the 38 respondents in the questionnaire.\(^\text{25}\)

1. The students interviewed reported that the grid charting as a model presented the entire information system and its details in an

\(^{22}\text{Supra, p. 131, Table 27.}\)

\(^{23}\text{Using the formula } \bar{X} \pm \frac{2\sqrt{pq}}{\sqrt{n}}.\)

\(^{24}\text{Supra, pp. 140-41.}\)

\(^{25}\text{Supra, p. 133, Table 28.}\)
easily comprehensible form. The systems analysts said that grid charts provided a permanent record of the system, provided for a rapid understanding of the system, quickly revealed the behavior of each data element, and uncovered unnecessary and redundant data elements.\textsuperscript{26} The supervisory analysts cited the ability to include and trace the frequency of reports and data elements as a primary advantage. They also said that the grid charting technique provided a capability for analysis and design of large data flows that was lacking in flow charts and facilitated the analysis of data and flow logic of computer runs.\textsuperscript{27} The lead programmers reported that grid charts provided a road map to develop the new system, clarified input and output relationships of data, facilitated the tracing of program logic, provided a capability to research data elements quickly, and facilitated the identification of equivalent and redundant data elements. The combination of grid charts and decision logic tables to represent a large, cumbersome file maintenance computer program, provided the detail necessary to identify the inefficient segments.\textsuperscript{28} Both the users and others cited the ease of recognition and understanding provided by the grid charts. The users also said that decision logic tables clarified management information needs and facilitated the identification of the action-to-information relationships.\textsuperscript{29}

2. The students reported that the grid charting technique as a

\textsuperscript{26}\textsuperscript{supra}, p. 135. \hspace{1cm} \textsuperscript{27}\textsuperscript{supra}, p. 139.

\textsuperscript{28}\textsuperscript{supra}, p. 143. \hspace{1cm} \textsuperscript{29}\textsuperscript{supra}, pp. 145-46.
model could be manipulated and showed the effects of system changes.

The systems analysts reported that grid charts quickly revealed the behavior of each data element, and uncovered unnecessary and redundant data elements.\textsuperscript{30} The supervisory analysts reported that grid charts provided the ability to trace changes in reports and data, and facilitated data elements analysis.\textsuperscript{31} The lead programmers reported that grid charts provided a capability to research data quickly.\textsuperscript{32}

3. The systems analysts, the systems supervisors, and the lead programmers interviewed indicated that flow charts could not compete with the grid charting technique.\textsuperscript{33} Flow charts that display data processes become large and cumbersome in large systems since their lines and connectors become too numerous and the logic difficult to follow. The analysts said that flow charts were acceptable for small systems but cumbersome for large systems.\textsuperscript{34} The supervisory analysts said that with the present masses of data in our systems, it takes several months to discover deficiencies, even with system flow charts.\textsuperscript{35} The analysts and supervisors both said that the grid charting technique provided a capability for analysis and design of large data flows that was lacking in flow charts.\textsuperscript{36} The supervisory analysts also said that grid charts and flow charts could complement each other since grid

\begin{flushleft}
\textsuperscript{30}\textit{Supra}, p. 135. \\
\textsuperscript{31}\textit{Supra}, p. 139. \\
\textsuperscript{32}\textit{Supra}, p. 146. \\
\textsuperscript{33}\textit{Supra}, p. 136, p. 139, p. 143. \\
\textsuperscript{34}\textit{Supra}, p. 135. \\
\textsuperscript{35}\textit{Supra}, p. 139. \\
\textsuperscript{36}\textit{Supra}, p. 135, p. 139.
\end{flushleft}
charts displayed data element relationships and flow charts displayed data processes.\textsuperscript{37}

**Disadvantages of the grid charting technique**

This study did not reveal any meaningful disadvantages of the grid charting technique. Only one systems analyst felt that grid charts were hard to follow in tracing the flow of a document through a computer but he had not attempted to use grid charts or decision logic tables.\textsuperscript{38}

**Modifications to the grid charting technique**

This study did not reveal any modifications nor did it disclose the need for any modification to the grid charting technique. Although the questionnaire data showed that 41 students reported a need to modify their grid charts\textsuperscript{39} and 18 students reported a need to modify their decision logic tables,\textsuperscript{40} the interviews disclosed that these modifications referred to the display of computer tapes, tape records, tape files, and tape units, since only paper documents, files, and reports were used in teaching the technique.\textsuperscript{41}

**Limiting factors of the grid charting technique**

A number of factors, direct and indirect, that limit the use of the grid charting technique were revealed:

\textsuperscript{37}Supra, p. 139. \quad \textsuperscript{38}Supra, p. 137.

\textsuperscript{39}Supra, p. 105, Table 5. \quad \textsuperscript{40}Supra, p. 108, Table 9.

\textsuperscript{41}Supra, p. 136, p. 138, p. 143.
1. Lack of a planned approach in systems effort is evidenced by the inconsistent directives received from top management. This limiting factor was corroborated by the systems analysts who said that analysts were not doing what they were supposed to do because there was a lack of consistent definition of the analyst's job and there are too many administrative duties or special assignments. The supervisory analysts reported that they were too busy making piecemeal changes, were not provided with a specific organization-directed way of doing systems work, didn't know how far to let the analyst go in system design, cited the lack of standard procedure, and stressed a need for specific documentation requirements. The supervisors scored the real need for more knowledge of how computers are being used today which also lent credence to the lack of a planned approach in systems effort.

2. The use of the grid charting technique by the analysts and specialists has been restricted by management. In the questionnaire, the same two analysts answered that "they had been requested or directed not to use" grid charts or decision logic tables. The specialists tended to corroborate the analysts' viewpoint because they said that the course content was very good but use of what was learned

42 Supra, p. 141.  
43 Supra, p. 137.  
44 Ibid.  
45 Supra, p. 139.  
46 Supra, p. 140.  
47 Supra, p. 141.  
48 Ibid.  
49 Ibid.  
50 Supra, Table 20, p. 119, Table 23, p. 122.
was restricted. They felt that the system cycle was political in nature and one doesn't have time to use grid charts. The supervisors reported that the grid charting technique can be used in some areas but not generally.

3. The pressure of short time schedules forces the use of traditional techniques and precludes risking the use of any new techniques. The analysts, the supervisory analysts, the programmers, and the lead programmers reported their use of flow charts under the pressure of limited time during the interviews. Although the press of time precluded the use of the grid charting technique during system development, the supervisors reported that even with system flow charts it takes several months after implementation to discover system deficiencies.

4. A cautious attitude in systems supervision was revealed when one of the supervisors said that he did not tell his analysts how to do their work nor what techniques to use. The analysts reported that they are restricted to a small area or part of a function, they are not allowed to cross functional or organizational boundaries, and too

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51 Supra, p. 138.  
52 Ibid.  
53 Supra, p. 140.  
54 Supra, p. 137.  
55 Supra, p. 141.  
56 Supra, p. 142.  
57 Supra, p. 144.  
58 Supra, p. 141.  
59 Ibid.  
60 Supra, p. 137.
much stress is being placed on the computer by management. This was corroborated by the supervisors who said that the authority, or importance, placed on the analyst's role is extremely restricted in government. The supervisors also stressed a lack of understanding of the role of systems effort on the part of the user even to the point of open resistance. If the users in their function refused to accept the recommendations of the systems analyst, there was no other place for the systems analyst to go for support of his recommendations.

Also, the programmers stated that their work was limited by management and corroborated the analysts point of view.

5. Of the 121 students who reported "no opportunity to use" grid charts, 43 were systems analysts and 12 were systems specialists. Of the 154 students who reported "no opportunity to use" decision logic tables, 54 were systems analysts and 20 were systems specialists. These are the positions with the greatest potential for use.

The analysts interviewed said that a lack of consistent definition of the analyst job restricts the analyst to small areas of activity, restricts him from crossing functional or organization boundaries, and subjects him to a narrow span of activity. The specialists said that their fire-fighting type of work didn't require or provide an opportunity to use grid charts.

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61 Ibid.
62 Supra, p. 140.
63 Ibid.
64 Supra, p. 142.
65 Supra, Table 20, p. 119.
66 Supra, Table 23, p. 122.
67 Supra, p. 137.
68 Supra, p. 138.
6. Too much stress on the computer tends to pervade the systems effort. The specialists felt that information systems cycles were political and tended to generate too many political problems for them to solve. The analysts felt that too much stress was placed on using the computer by management and could only escape such pressure by being programmers or in positions above such pressures.

7. A shortage of qualified personnel was indicated as a basic problem and deduced from a number of interviews. The specialists said that the basic problem is a lack of qualified persons. Also, the supervisory analysts said the authority or importance of the analysts' role is severely restricted in government and one can deduce that this is true since the amount of delegated responsibility is directly related to capability. The degree of productive effort in systems depends upon the capability of the analysts and the limits of activity set for the analysts by management. The analysts' complaint was that they were not doing analyst work and they did not have consistent definition of the analyst's job. Such a lack of consistent criteria allows unqualified personnel to survive and escape effective evaluation by management. The reluctance to use any new techniques, even in the face of short time schedules and the known limitations of flow charts, indicates a lack of confidence in the capability of the systems personnel.

Ibid.
Supra, p. 138.
Supra, p. 137.
Supra, p. 137.
Supra, p. 138.
Supra, p. 140.
Supra, p. 140.
Supra, p. 157.
CONCLUSIONS

The primary purpose of this study was to evaluate the grid charting technique developed as a model for the analysis and design of large scale integrated management information systems as exemplified by the Air Force Logistics Command. Based on the analyses and findings, the following conclusions may be stated:

1. The grid charting technique as a model for large-scale management information systems presents the entire system and its details in an easily comprehensible form, can be manipulated, and shows the effects of system changes. These accomplishments were evidenced in the interviews of the students using the technique. They said that the technique provided a system roadmap, facilitated analysis and design of large data flows, and facilitated the tracing of data elements and computer flow logic. Also, the technique revealed the behavior of individual data elements, provided the ability to trace changes in reports and data, and facilitated the analysis of data changes.

2. The full benefit of the theory of management information systems, the theoretical base for the grid charting technique, has not been achieved due to the newness of the field and its purpose. The theory has been useful to a majority of the students surveyed; however, it has provided more informative value than use value for the students. Although the analysts, the specialists, the supervisory analysts, the programmers, and the lead programmers reported the largest contributions to their technical knowledge, they also reported the lowest values in use in their professional work.
3. The grid charting technique has been useful to a majority of the students who reported use of grid charts and decision logic tables.

This same majority reported that the technique facilitated analysis, facilitated design, and was worth the effort. However, only a minority of the students surveyed reported use of grid charts and decision logic tables primarily because management has limited the use of new techniques. The reason most frequently stated during the interviews was that the pressure of short time schedules precluded the risk of using any new techniques.

4. The fact that grid charts have been used more extensively than decision logic tables indicates that systems effort has been limited to the automation of information.

Evidence to this effect was found in the validity arrays on system boundaries which indicated that systems boundaries were rigidly defined before the study was begun. Also, the interviews revealed that too much stress was placed on use of the computer and not enough stress was placed on the analysis and design of the management information system. This was further evident in the factors most frequently displayed in the grid charts as the factors found in the automated data processes.

5. The grid charting technique provided a capability for analysis and design of large-scale management information systems that is lacking in flow charts.

Students interviewed reported that the lines and connectors in flow charts of large systems make logic difficult to follow. The
supervisors reported that even with systems flow charts, it often takes
several months to discover difficulties in systems. Grid charts were
used to portray data relationships and flow charts were used to
portray data processes by the students. The supervisors who used grid
charts and decision logic tables said they found them to be superior to
symbolic flow charts. They also said that flow charts were adequate
for small systems but not for large systems.

6. The grid charting technique has no meaningful disadvantages.
The grid charting technique as presented to the students was used in
the intended manner. There was no need for modification to the
technique nor any disadvantages in its use cited.

7. The use of the grid charting technique by the analysts and
specialists has been restricted by the supervisory analysts.
The supervisors interviewed said that short time schedules forced
their use of traditional techniques and precluded the risk of any new
technique. The analysts, lead programmers, and programmers corroborated this fact during their interviews. The short time schedules are
the result of a lack of a planned approach in systems effort. The
supervisors stated that they didn't know how far to let the analysts go
in systems analysis and design. Although a systems design tools and
techniques office instruction existed, the supervisors interviewed cited
the lack of standard formats, forms, and procedures. The specialists
said their use of the technique was restricted by management.

8. In respect to systems analysis, there is a strong indication
that job titles, job functions, and personnel capabilities are mis-
matched or poorly defined.
Although lead programmers were small in number, they reported more use of grid charts and decision tables per man than did the systems analysts and systems specialists. The supervisory analysts cited the problem of the overlapping division of work between analysts and programmers. One cannot overlook the deduction that lead programmers, trained to think abstractly and logically, more readily know what information they need to write computer programs and may tend to circumvent the analyst.

9. Systems analysts and specialists have been limited to mechanization of existing procedures by management because of the emphasis placed on using computers, a lack of understanding of the role and activity of the analyst, and a lack of qualified personnel.

The absence of a master plan for logistics management information systems, evidenced by the lack of a planned approach in systems effort can only result in the automation of existing procedures. The analysts stated that too much emphasis was placed on using computers and there was a lack of consistent definition of the analyst's job. They also said they were not allowed to cross functional and organizational boundaries. The mechanization of existing procedures does not require crossing of functional and organizational boundaries. However, more effective use of information always results in integrated management information systems that cross functional and organizational boundaries. The supervisors said that functional management lacks an understanding of the role and scope of systems activity. Analysts have no recourse when functional management
refuses to accept their recommendations. The specialists said that the basic problem in systems is a lack of qualified personnel. The rate of return from an investment in systems effort depends upon the capabilities of the systems analysts and the scope of activity set by management for the systems analysts.

**RECOMMENDATIONS**

The findings and conclusions of this study provided the basis for the following recommendations:

1. That management above the supervisory analysts' level be exposed to the theory of management information system and the grid charting technique.

   Such exposure will vividly demonstrate the need for and the type of planning required for integrated management information systems. Also, a better understanding of the role and activity of the analysts would be developed and a clearer definition of the duties and responsibilities of the analyst, programmer, and user would result.

2. If the full potential of the grid charting technique is to be reaped, then existing directives, policies, and procedures manuals must be amended to reflect management's approval of the technique.

3. That a comprehensive study of the job titles, job functions, and personnel capabilities in systems analysis be accomplished.

   This study should provide the basis for enhancing the capabilities of analysts to fulfill their role as management consultants.

4. The role of the analyst must be raised to a level commensurate with that of a consultant to management with a clear channel to an administrative executive in top management.
This would provide a countervailing balance of executive power to assure that the information systems developed meet more of management's information needs and to prevent functional bias from interfering with information integration. Accordingly, the analyst must be capable of accomplishing the duties that would be so delegated. More effective utilization of the analyst's knowledge could be employed on short term staff studies. The lack of definition and understanding of the role and activity of the analysts has forced his restriction to a more limited scope of work.

5. Management must allow the analyst to cross functional lines in order to assure that side effects, spillovers, and inter-relationships between systems are identified and properly considered when system changes are effected.

The students reported that they were not allowed to cross functional lines, were limited in their scope of activity, and had no recourse if functional line management did not accept their recommendations for changes necessary to the effective or efficient operation of the information system under development.

6. Management should deemphasize the role of the computer and implement a reassessment of management information needs.

Information is an accountable resource that incurs cost. A reassessment of management information needs can be spurred by instituting responsibility accounting for information. The absence of a hierarchy of objectives or a master plan for management information systems has generated a cautious attitude in the middle management and has forced middle management to limit their systems
activities and efforts. This attitude in management has resulted in insufficient time to design and develop information systems. The one limiting factor echoed by the analyst, the specialists, the supervisory analysts, the programmers and the lead programmers was that they are too rushed for time by management to risk the use of any new technique in developing an information system.

7. That research be conducted in the area of accuracy of source data.

Only two research efforts have been accomplished to date: a doctoral dissertation by Gary Carlson at the University of California at Los Angeles, 1962, on the types of errors in 8,000,000 bank checks and an experiment conducted by the Human Factors Section of the Air Force Systems Command for the Air Force Logistics Command. Both of these efforts remain unpublished. Unless more is known about the causes of errors in source data, the most competent information systems designers will continue to design error prone systems.

8. That research be conducted in general purpose simulation of management information systems.

Viewed as a laboratory for managers to test changes in policy or procedure, general purpose simulation offers a wide field for research because so little is known about this type of simulation in management. General purpose simulators are virtually non-existent with one exception. That exception is the "Job Shop Simulator" developed by Allan Rowe at The General Electric Company, Incorporated and published by the International Business Machines Corporation.
APPENDIXES
A MATHEMATICAL MODEL FOR
INTEGRATED BUSINESS SYSTEMS

by

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An address presented at the
Second National Meeting of
The Institute of Management
Sciences
New York City, New York
October 20-21, 1955
We agree with Dr. Kircher that the business firm is not merely "facts", modified by logic, engineering, and intuition forming communication networks among rational individuals with predictable reactions.

Nevertheless, we can safely assume that intercommunication of facts is necessary for continuance and that the prosperity of the firm does depend to a significant degree on the efficiency, effectiveness, and application of facts toward operations throughout the enterprise.

The form and manner of data transmittal must be prescribed and organized. It is this portion of the problems of management that the considerations in this paper are directed.

To further designate the boundaries of the problems we are investigating, let us look at the total problem in the following manner:

At all times we are concerned with an entity that defies thorough definition or description, but we hope to make it operate as "an integrated business system" that attempts to adjust optimally to its changing environment.

We might, therefore, divide up our conception of our integrated business system in some major areas. Those concerned with information we can designate as

a. Integrated Data Processing
b. Control of the System and Its Parts
c. Decision-Making Process
d. Management Conclusions

Though none of these functions is independent of the others, it is our purpose at this time to focus our attention on the first, that is, the problem of providing efficient data processing for disseminating effective information through our "integrated business system."

Recently there have been numerous investigations of methods to integrate the data processing of an organization. Most of these have been instigated by the thought of the potentialities of electronic computer systems. In order to efficiently utilize electronics systems, techniques have been devised to translate into machine language the source data of various functions of an organization, e.g., accounting, production, sales, personnel, etc. This "common language" approach is fundamental to a truly integrated data processing system.

Data collection and processing is only a part of the business system. We ask, what are the information requirements of a modern enterprise? Management must know how well their carefully laid plans are faring. If something goes wrong there must be some corrective action. Thus, reports must be timely, as well as able to pin-point the source of any trouble. Few reporting systems serve their purpose well in the
control and decisions situations.

The utilization of electronic processing equipment has helped to lighten the burden of preparing reports. Information can now be processed faster and the necessary data transmitted to management sooner. But we still have no answer to the basic question. Once the requirements are established, electronic processing gives us the means to satisfy them. We are on the way to getting our answer. Many of you have probably experienced or heard of cases where a change in a processing technique has led to a change in the business system and where most of the gains made can be attributed to the system change. In fact, reversion to older processing techniques and further system changes sometimes result in even greater gains. These results highlight the need for continued work in analyzing the business system. Also, it points to the lack of a good working description of the system.

The business system can be thought of as a communication network. Information is disseminated from one point and used at another. Thus a worker originates information which is used by the foreman as well as assembled by the accounting department for reporting to various other points in the organization. The organization can thus be described in terms of the communication network or information flow.

Descriptions of such a communication (business) system are seen in the flow diagrams of the system analyst. Those diagrams which integrate the complete system of an enterprise have proven to be cumbersome and incomprehensible. The analyst has, therefore, broken the diagrams into parts corresponding to the various functional parts of the organization. These are woven together by still another chart which leaves out the details of each of the parts and gives an overall view. The analyst has now built a model of an organization by parts in which it is difficult to look at the totality in detail.

What the systems man would like to devise is the optimum system which satisfies the information requirements of the enterprise. To obtain this, he must build a model of the business system which simultaneously:

1. Presents the total system in an easily comprehensible form.
2. Presents the details of the system.
3. Has a method for manipulation.
4. Shows effects of system changes.

If the model could accomplish all of these, then the analyst would be able to answer the question, "What are the information requirements?" The usual flow diagram accomplishes but one or two of the desired results. What I propose in this paper is a mathematical technique for investigating integrated business systems. This technique will be based on the mathematical notion of matrices.

The model presented here is by no means the complete model of a busi-
ness system. It is the simplest one which will be considered, but is useful. Now let us consider only the formal reporting structure. By investigating this model it will become apparent that a more sophisticated version, to be described at some later date, could meet the requirements for a model of an integrated business system. Here we shall construct matrices which will describe the details of the data flow as well as the overall picture. Manipulating and examining the matrices will answer some of the questions which the systems analyst asks. The result of this manipulation will be other matrices which will indicate the availability of data as well as a measure of its usefulness and redundancy. Further developments in this technique will be indicated at the end.

Elements of the matrices will determine the relationship between information and the communication of information through source documents and reports to various parts of the organization. It is practical to consider the structure of the system from the viewpoint of function within the organization. We shall consider an existing (or proposed) data collecting and processing system. In this network there will occur first the original or source data. This source information will be put on source forms from which, by various operations, report forms will be prepared. There will usually be a number of stages or reporting before the information is used in some function. You will notice that the lowest level in the reporting structure—the source of data—can be workers, foreman, or even the president of the company. Therefore, the reporting level cannot be compared to management levels. But in general, the number of reporting stages probably will be about the same as the number of management levels.

Before we can proceed to build the model, it is necessary to define the symbols and terms which will be used in constructing the matrices. These definitions are not rigid and are used only to convey the concepts of the model.

"B", a Business Function, we define to be a set of managerial activities which are assigned to a group according to types of duties.

In this definition we are trying to separate the various aspects of control or action taking in the organization. The functions are usually fairly well recognized within an organization: but if they are difficult to define, then for our purposes they may be grouped in some arbitrary manner. Examples of business functions are purchasing, accounting, production operations, inventory operations, budgeting, etc.

In this treatment we shall consider,

"C", a Class of Information consists of one or more pieces of information having all common qualities. A class may have any number of members.

What we are essentially trying to do is differentiate between the
kind of information and the quantitative measure of that kind of information. For example, the straight time hours, overtime hours, total hours, name, date, etc., are all different classes or kinds of information and the number of overtime hours worked, etc., is the quantitative measure of that particular class of information. Thus two different people work overtime hours, which belong to the same class of information which may have different quantitative measures.

We shall distinguish between two different types of classes of information. First there is the

**Identification type of class of information**: (i)
These classes describe or identify a form or document.

As examples of this type of information class we have date, invoice, number, purchase order number, name, address, description of material, etc., all tending to identify the document. While the number of hours worked, number of pieces ordered, number of people, etc., all are examples of the

**Quantitative type of class of information**: (q)
These are the classes of information which give a quantitative measure.

Information is entered on a document or form. The distinction between forms and documents is given by the following definitions for a

**Form**: (F) Two documents are said to be the same form if they have all of the same classes of information and no other classes.

An example of two different documents are two timecards, one for one person and another for someone else, or one for you on one day and the other for some other day. In both cases these timecards are the same form.

Another concept which we have mentioned are report and source forms. They are defined as follow:

**Source data forms**: (S) Those forms upon which information is recorded for the first time and is not obtainable from any other form by using some operation or combination of operations.

**Report forms**: (R) Those forms which arise from performing an operation or combination of operations on Source Data forms.

With these definitions and symbols in mind, we are now in a position to construct a matrix model. The first matrix constructed will display the classes of information which are used in each source data
form.

What we want to know about the relationship of the information and the forms is whether a class of information is used or not used in a source form. The cell which is designated by the intersection of the column headed by the name or symbol for the form and the row headed by the name or symbol of the information will contain a 1 or 0 according to whether the information is used or not used in that particular form. Thus, if the source forms are listed in a row on top and all the classes of information in a column on the left hand side of a matrix, the remainder may be filled in with 1's and 0's as required.

This first matrix we shall call \( M_s \). If there are \( n \) classes of information and \( m \) forms, then there will be \( n \) rows and \( m \) columns.

Let us fill in a typical matrix, \( (M_s) \).

<table>
<thead>
<tr>
<th>SOURCE DATA FORMS</th>
<th>Time Card</th>
<th>Labor Realisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classes of Information</td>
<td>( S_1 )</td>
<td>( S_2 )</td>
</tr>
<tr>
<td>Identification ( (i) )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Date).................................. ( i_1 )</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>(Department).......................... ( i_2 )</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>(Section).............................. ( i_3 )</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>(Name).................................. ( i_4 )</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>(Employee #).......................... ( i_5 )</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>(Shift)............................... ( i_6 )</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>(Job #).............................. ( i_7 )</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>(Machine #)........................... ( i_8 )</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Quantitative ( (q) )</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Straight Time Hours)...................... ( q_1 )</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>(Overtime Hours)......................... ( q_2 )</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>(Rate of Pay)........................... ( q_3 )</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>(# of Pieces Made)....................... ( q_4 )</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>(# of Pieces Bad)....................... ( q_5 )</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

In a similar manner the other matrices are constructed.
$M_1$, the matrix of source data forms used in the first reporting level is completed. The level of reporting is denoted by a superscript to the symbol $R$. Subscripts distinguish between the different report forms.

$$
\begin{array}{cccc}
R_1 & R_2 & \cdots & R_D \\
S_1 & b_{11} & b_{12} & \cdots & b_{1p} \\
S_2 & b_{21} & b_{22} & \cdots & b_{2p} \\
\vdots & \vdots & \vdots & \ddots & \vdots \\
S_m & b_{m1} & \cdots & \cdots & b_{mp}
\end{array}
$$

Matrix $(M_2)$, the first level reports used in the second level of reports is constructed.

$$
\begin{array}{cccc}
R_1 & R_2 & \cdots & R_v \\
R_1 & C_{11} & C_{12} & \cdots & C_{1v} \\
\vdots & \vdots & \vdots & \ddots & \vdots \\
R_v & C_{pl} & \cdots & \cdots & C_{pv}
\end{array}
$$

As many matrices as are needed for the particular system under consideration are constructed in a similar manner.

It is often said that there are usually 4-6 levels of management, and therefore, 4-6 matrices of the above type. Thus after some finite number of steps as above we come to the last matrix which is to be filled out. This represents which functions use each report. This last matrix is constructed as follows:

$$
\begin{array}{cccc}
R^2 & B_1 & B_2 & \cdots & B_w \\
R^2 & d_{11} & d_{12} & \cdots & d_{1w} \\
\vdots & \vdots & \vdots & \ddots & \vdots \\
R^2 & d & \cdots & \cdots & d \\
v & v_1 & \cdots & \cdots & v_w
\end{array}
$$

We now scrutinize each matrix for certain criteria. If the sum of the elements of a row is greater than or equal to one, then this indicates there is usefulness to that particular information and gives an index of that usefulness (sum = 0, means it is useless). It also tells us how many times the same information is repeated. If the sum of the elements of a column is greater than or equal to one then this indi-
cates the amount of information in that form which heads the column (sum = 0, means no information is used in the form).

This may be useful in designing the forms.

Now we manipulate the matrices, by the usual matrix multiplication technique, in a number of ways. We may, for example, find the $R^1$'s available to the functions, $B$'s, or the $i$'s and $q$'s available to the $R^2$'s etc. At each stage we can analyze the result according to the criteria of usefulness, redundancy, and amount of information. We can then get the basic data "$i$'s" and "$q$'s", used in the function $(B)$.

Let us follow a theoretical example through this system. First we construct the matrices.

\[
\begin{array}{cccccc}
S_1 & S_2 & S_3 & S_4 & S_5 \\
\hline
i_1 & 1 & 0 & 0 & 1 & 1 \\
i_2 & 1 & 1 & 1 & 0 & 1 \\
i_3 & 1 & 0 & 0 & 1 & 1 \\
i_4 & 1 & 0 & 0 & 0 & 1 \\
q_1 & 1 & 0 & 0 & 0 & 1 \\
q_2 & 0 & 0 & 1 & 0 & 1 \\
q_3 & 0 & 1 & 0 & 1 & 0 \\
(\text{M}_3) & & & & &
\end{array}
\]

\[
\begin{array}{cccccccc}
F_1 & F_2 & F_3 & F_4 & F_5 & F_6 \\
\hline
S_1 & 1 & 0 & 0 & 1 & 1 & 1 \\
S_2 & 0 & 0 & 1 & 1 & 0 & 0 \\
S_3 & 0 & 0 & 0 & 0 & 1 & 0 \\
S_4 & 0 & 1 & 1 & 0 & 0 & 1 \\
S_5 & 1 & 1 & 0 & 0 & 0 & 0 \\
(\text{M}_1) & & & & &
\end{array}
\]
What can we find out at this point? Returning to $M_5$, let us sum the elements in each row and column. These numbers indicate the relative amount of information on each form and the number of times the same information is used on different forms.

1. $S_5$ contains nearly all the information.
2. $S_2$ contains very little information.
3. $i_2$ appears in nearly all the source forms, and so on. This can be done for each of the matrices.
It is evident we can now try to eliminate some of the duplication of information. Multiplying the matrices:

\[
\begin{align*}
\begin{array}{cccccc}
S_1 & S_2 & S_3 & S_4 & S_5 & \text{Sum} \\
i_1 & 1 & 0 & 0 & 1 & 1 \\
i_2 & 1 & 1 & 1 & 0 & 1 \\
i_3 & 1 & 0 & 0 & 1 & 1 \\
i_4 & 0 & 0 & 0 & 1 & 1 \\
q_1 & 1 & 0 & 0 & 0 & 1 \\
q_2 & 0 & 0 & 1 & 0 & 1 \\
q_3 & 0 & 1 & 0 & 1 & 1 \\
\end{array}
\end{align*}
\]

\[
\begin{align*}
\begin{array}{cccccccc}
F_1 & F_2 & F_3 & F_4 & F_5 & F_6 \\
1 & 0 & 0 & 1 & 1 & 1 & 1 \\
0 & 0 & 0 & 1 & 1 & 0 & 0 \\
0 & 0 & 0 & 0 & 1 & 0 & 0 \\
0 & 1 & 1 & 0 & 0 & 1 & 0 \\
1 & 1 & 0 & 0 & 0 & 0 & 0 \\
\end{array}
\end{align*}
\]

\[
\begin{align*}
\begin{array}{ccccccc}
F_1 & F_2 & F_3 & F_4 & F_5 & F_6 & F_7 \\
2 & 2 & 1 & 1 & 1 & 2 & 1 \\
2 & 1 & 1 & 2 & 2 & 1 & 1 \\
2 & 2 & 1 & 1 & 1 & 2 & 0 \\
1 & 2 & 1 & 0 & 0 & 1 & 0 \\
2 & 1 & 0 & 1 & 1 & 1 & 0 \\
0 & 1 & 2 & 1 & 0 & 1 & 0 \\
\end{array}
\end{align*}
\]

\[
\begin{align*}
\begin{array}{ccccccc}
F_1 & F_2 & F_3 & F_4 & F_5 & F_6 & F_7 \\
1 & 0 & 1 & 1 \\
1 & 1 & 0 & 0 \\
0 & 0 & 0 & 1 \\
1 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 \\
1 & 0 & 0 & 1 \\
\end{array}
\end{align*}
\]
The resultant matrix indicates the classes of information available to each of the business functions. The number of times this infor-
Information is available to each function is indicated by the number at their intersection. This gives a measure of the redundancy in the processing.

Let us follow an example through the system. The first matrix shows that \( i_1 \) occurs in \( S_1, S_4 \) and \( S_5 \) which are used in preparing the \( F^1 \)'s. Multiplying these matrices results in \( i_1 \) being available to all of the \( F^1 \)'s, and available to some of them from more than one source.

The next multiplication results in a matrix in which the information is available to the next level of reporting, \( F^2 \). This shows that \( i_1 \) is available to \( F^2_1 \) seven times. The number seven is seen to come from the previous result plus the occurrence of \( F^1_1, F^1_2, F^1_4, \) and \( F^1_0 \) in preparing \( F^2_1 \). In a similar way we look at the information available to the \( F^3 \)'s and the business functions.

It was not necessary to start with the information (\( i \)'s, \( q \)'s), we could have started from the opposite end and found the \( F^2 \)'s used in the \( B \)'s, the \( F^1 \)'s available to the \( F^3 \)'s or the \( B \)'s, etc.

Thus we have a model that can be investigated and manipulated. If changes are made at any stage, the results of these changes on the rest of the system will immediately become apparent. When a desired result is known, i.e., the \( i \)'s and \( q \)'s available to the \( B \)'s, then by "inverting" the matrix the previous matrix can be found. By progressively "inverting" each matrix all the matrices become known. In this way an optimum system can be devised. Notice also the size of each succeeding matrix does not necessarily increase.

If we consider the reporting structure as only a part of the communications within the organization we can see immediately that there is also an informal communication network existing. The formal reporting structure is always augmented by the informal, by people in various functions speaking to people in other functions. In many cases this informal structure is more effective in controlling the operation than the reporting structure. Thus the informal communication network must be woven into our model.

There are several ways to construct the informal communication model;
each depends on the amount of information which can be obtained about the structure. One technique is to consider the information being communicated between the various functions. Then we may construct the following matrices:

\[
\begin{pmatrix}
  k_{11} & k_{12} & \cdots & k_{1n} \\
  \vdots & \ddots & \ddots & \vdots \\
  k_{n1} & k_{n2} & \cdots & k_{nn}
\end{pmatrix}
\]

\[
\begin{pmatrix}
  b_{11} & b_{12} & \cdots & b_{1n} \\
  \vdots & \ddots & \ddots & \vdots \\
  b_{n1} & b_{n2} & \cdots & b_{nn}
\end{pmatrix}
\]

The matrix resulting from multiplying $I_1 \times I_2$ then corresponds to the resultant matrix of the formal system. Therefore, the total system - both formal and informal - may be constructed in an integrated model.

A modification to this model can be made with the introduction of a timing notation. This will give us a relationship of the periodicity of the information flow. Also, the time it takes to go from one stage to the next - the lag time - must be considered.

The model can be made to describe the real information flow and processing by the introduction of operation matrices. This gives us the facility to reduce the system to a minimal from the operating and economic point of view. These models will be described at some future date.

The value of these matrices does not lie in the fact that they show anything which could not be represented in other ways, e.g., by 300 foot rolls of paper, or voluminous manuals. Rather, the value lies in the fact that the analyst has called upon mathematics for presentation of information in condensed and manipulable forms.

Not only does the model enable the analyst to picture the whole of a very complicated situation in a relatively simplified form, but the model offers other advantages. For example, because the relationships are delineated and grouped so precisely, it becomes relatively easy to divide the systems study work among the members of an analysis group. Each can be given a different part of the study, with precise knowledge as to how their part fits into the whole picture.

Equally important, because the items are defined clearly and their flows established, it becomes much easier to provide the electronics engineers with the volume, quality and routing specifications which are so hard to obtain for present data processing systems. It is in
this direction that improvement in special electronic systems can
most profitably be sought.

Another advantage is the experimentation which can be carried on with
the model, to determine the effects of certain suggested system changes,
without disturbing the actual system. This is a scientific advantage
which it is almost impossible to obtain using present methods. In
present systems, the direct effects of a systems change can usually be
foreseen, but the second and third order effects, together with over­
laps and other difficulties, are almost impossible to determine in
advance. Indeed, they frequently go unrecognized even after the
system change is put into effect. Efficiency suffers, but the cause
is not ascertained.

Comparison of information transferred by the informal system, and that
by the formal net, will give a new picture of the communication procesa.
It will be possible to decide the extent to which the informal net
should be encouraged, the amount of data which should be repeated over
the formal net for verification purposes, and so on.

There are many other advantages afforded by the use of this type of
model. However, the last we shall mention here is the important
opportunity which is offered the analyst to incorporate in his system
the advances which are taking place in programming, scheduling and
feedback—both conceptually and in terms of electronic equipment.
DEFINITION OF TERMS USED

A complete list of terms used in this study is given below.
Numerous references were used as resource material for the definitions assembled for this study. Authors were cited at the end of each definition extracted verbatim.

**Basic:** An organic function of information that refers to any set of data maintained periodically for normal business activities and whose primary purpose is for reference.

**Basic Record:** any document or form maintained periodically to record the historical status of business activities. Its primary purpose is for reference only, such as an inventory file, a personnel record, a payroll register, or an accounts receivable ledger.

**Boundary:** the limits encompassed by a system, the scope of a system, or the definition of a system.

**Communication System:** meaningful or useful data that represent the resources of a resource system, that work toward some specified objective, and which aid management in decision making.

**Control:** the management function which correlates and coordinates action in accordance with a plan; a system element which describes all of the how factors that must exist for an on-going process to operate.

**Criteria:** a set of goals or objectives, specifically and rigidly defined in quantitative measures.
**Data Element**: a specific item appearing in a set of data; e.g., in the following set of data, each item is a data element: the quantity of an item, the unit price, and the balance on hand.

**Data System**: a large scale information system of the United States Air Force that is automated and employs at least one computer as a processor.

**Decision Logic Tables**: rectangular arrays that portray related decision conditions to actions.

**Decision Tables**: a shortened form for decision logic tables.

**External Balance of Capability**: the ability of a system to match the demands imposed upon that system.

**Factor**: one of the elements that contribute to produce a result.

**Feedback**: a system element of the module that relates output to input and may or may not cause an adjustment to input.

**Final**: an organic function of information that refers to any set of data used in management planning or controlling, or essentially management decision making and meets a management information need. Such data sets should not require any further processing in serving this final function.

**Final Report**: any document, form, or other paper used in management planning and controlling, or essentially decision making. The final report should not require any further processing.

**Fixed Data Element**: a data element, whose content is not subject to change over long periods of time such as an employee's social security number.
Grid Chart: a matrix or rectangular array that portrays relationships between factors of information such as data elements, sets of data in reports, documents, basic records, source documents, punched cards, magnetic tape reels, and/or various management functions or activities. Any medium that carries information may be represented in the array. The arrays may portray any combination of factors.

Grid Charting Technique: the combined use of grid charts and decision logic tables to represent a management information system.

Identification Data Element: a data element that describes or identifies a document, resource, or any other factor.

Input: a system element of the module that describes all of the what factors that must exist for an on-going process to operate.

Intermediate: an organic function of information that refers to any set of data basically internal to a system and used primarily to facilitate the processing of data.

Intermediate Record: any document basically internal to a processing system and used primarily to facilitate the processing of data rather than as a final report of the system. An example would be: summary cards in a punched card system or work sheets in a manual system.

Internal Balance of Capacity: the flow relationships between the components in a system.

Inventory of Resources: the concept that treats every manager as an inventory manager of some combination of allotted resources by which he must accomplish his delegated responsibility of producing goods and/or services.
**Level of Indenture:** the layered structure within a system.

**Lieberman Model:** a mathematical model developed at Litton Industries in 1955 that uses matrix construction and multiplication to represent integrated business systems.

**Limiting Factor:** any business or physical factor that interferes with the accomplishment of the objectives of an on-going process or the generation of outputs in a system.

**Machine Debugging:** the process of identification and elimination of errors in a computer program.

**Management Information System:** a network of related cycles of data flows which produces final reports from source documents for management control and planning of a business function or a set of activities.

**Master Grid Chart:** one array of all input to output relationships in the entire system.

**Mathematical Model:** a theoretically precise substitute of the exact relations existing between factors of the real world.

**Measure of Performance:** See Criteria.

**Model:** a substitute for some real equipment or system.

**Module:** that combination of system elements used to describe an entire system or any part of a system. These elements are input, output, process or processor, control, and feedback.

**Organize:** the management function that assembles the resources enumerated in a plan.
Organic Business Function: functions in a field of business activity that are so vital that business activity will cease unless they are performed somehow, somewhere, at sometime, by someone, in the minimum degree required for the satisfactory achievement of primary service objectives. Usually classified as the creation of utility, distribution of the created utility, and capital—R. C. Davis.

Organic Information Function: functions of data or information differentiated by their purpose or use in an information system that are so vital that the information system would not continue as an ongoing process. Classified as final, intermediate, basic, and source.

Output: a system element of the model that describes the objectives, purposes, and/or the values produced by the ongoing process.

Plan: the management function that enumerates the resources required to accomplish a specified objective.

Process: a system element of the module that describes the particular activities under study.

Processor: a system element of the module that describes the mechanism that accomplishes the particular activities.

Quantitative Data Element: any data element that gives a quantitative measure or value.

Resources: people, material, and capital.

Resource System: combinations of people, material, and capital working toward an objective.
Scientific Management: an approach which seeks to apply the logic of effective thinking, based on a management science, to the solution of business problems—R. C. Davis.

Sequenced Grid Chart: one matrix or rectangular array that portrays the input to output relationships of a subsystem or module of the system.

Set of Data: a combination of data elements that serves one of the organic functions of information.

Side Effects: the result of a change to one system or subsystem that produces unplanned effects in related systems or subsystems.

Source: an organic function of information that refers to any set of quantitative data that first enter any information system.

Source Document: the form on which quantitative data first enter any information system.

Spillovers: see Side Effects.

Structured System: any system that has a machine-like processor, invariant inputs, and predictable outputs; usually a physical system—Oppner.

Suboptimization: an inherent limitation of all systems that prevents a total system from achieving its ultimate objectives.

System: an assembly of procedures, processes, methods, routines, or techniques united by some form of regulated interaction to form an organized whole; an on-going process.

System Analysis: the examination of an activity, procedure, method, technique, or a business to determine what must be accomplished and how the necessary operations may best be accomplished.
Systems Analyst: one who analyzes, improves, develops, and/or designs information systems for management.

Systems Approach: considers an enterprise to be a balanced system of interrelated functions working toward the enterprise objectives specified by management.

System Elements: input, output, processor, control, and feedback as parts of module.

Systems Engineer: synonymous with systems analyst but usually refers to one who deals in the physical systems or scientific systems.

System Purchaser: see System User.

System User: those persons who use the final reports produced by the information system.

Tabular Analysis: the process of structuring related decision conditions and actions into decision logic tables.

Theory: a more or less plausible or scientifically acceptable general principle offered to explain phenomena.

Three Basic Transactions: the three types of actions that are universal in any resource inventory. The actions are additions or inputs to the inventory, status changes within the inventory, and deletions or outputs from the inventory.

Unstructured System: any system that has man involved as the processor, variable inputs and unpredictable outputs; usually a business system—Opnner.

Validity Array: a two-dimensional matrix of the answers to two questions pertaining to the same subject.

Variable Data Element: any data element whose content is subject to change.
APPENDIX C

PERSONNEL OPERATIONS AND INFORMATIONS FLOW ANALYSIS

OBJECTIVES: Primary responsibility: personnel operations must plan, organize, and control the acquisition and distribution of human resources or people for corporation.

RESOURCES:

FUNCTIONS:

INVENTORY ACTIONS:

TRANSACTION DOCUMENT

<table>
<thead>
<tr>
<th>Data Element</th>
<th>HIRE</th>
<th>CHANGE STATUS</th>
<th>TERMINATE</th>
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<tbody>
<tr>
<td>Employee</td>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>Name</td>
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<td></td>
<td>D</td>
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<tr>
<td>Date</td>
<td></td>
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<td>Salary</td>
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<tr>
<td>Hourly Rate</td>
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</table>

01 Salary
02 Hourly Rate
APPENDIX D

Headquarters
AIR FORCE LOGISTICS COMMAND
United States Air Force
Wright-Patterson Air Force Base, Ohio

REPLY TO
ATTN OF: MCB

SUBJECT: USAFIT Support of AFLC Data Systems Education Requirements

TO: IT, Wright-Patterson, AFB Ohio

1. In the process of organizing the Hq AFLC Directorate of Data Systems one of our most difficult problems proved to be the education and training of a large technical staff. An especially difficult problem was that of providing a suitable educational foundation for personnel assigned as Digital Computer Systems Analysts. Our problem was somewhat unique because many of these personnel had been functionally transferred from a variety of occupational fields with little or no systems analysis or systems automation background.

2. Investigation disclosed that because this field of specialization is so new, no existing program of education was available which would satisfy our requirements. Moreover, no existing program could be found which could be used as a precedent or basis for developing a curriculum.

3. In early March 1961 we requested the USAFIT School of Logistics to develop a suitable 3-week course with an initial class objective of 12 May 1961, allowing only 60 days for developing a curriculum, arranging for faculty and guest instructors, developing or acquiring text materials and accomplishing attendant details. The pilot class began on schedule.

4. Representatives of the Directorate of Data Systems carefully monitored daily progress of the course, "Fundamentals of Data Systems Analysis". Upon completion of the pilot offering we conducted a comprehensive critique with the class. Following the critique each division chief personally interviewed those of his employees who had been a student of the class.

5. The results of our evaluations were, to say the least,
most gratifying. We are indebted to Colonel Green, Dr. Moeckel and Dr. Hurley of the School of Logistics for their cooperation and assistance. I would be remiss if I did not call to your personal attention the superb accomplishments of the Course Director, Mr. Gordon T. Shahin. His enthusiasm, his exceptional knowledge of the subject, his many long hours of preparation, his outstanding and inspiring direction and leadership of the class and his constructive suggestions to the Directorate, merit the highest commendation.

6. We look forward to continuing our excellent relationship throughout further offerings of the "Fundamentals of Data Systems Analysis" course, and in the development of a sequel course intended to advance the technical competence of those personnel who will have completed the course now under way.

FOR THE COMMANDER

FRANCIS GIDEON
Major General, USAF
Director of Data Systems

29 May 1961
(a copy)
MEMO TO: Graduates of Management 350 - Fundamentals of Data Systems

The School of Systems and Logistics, with the cooperation of the Air Force Logistics Command, is currently engaged in educational research.

Please complete the attached questionnaire promptly and answer all questions.


Your cooperation is greatly appreciated.

GORDON T. SHAHIN
Research Associate
School of Systems and Logistics
Bldg. 288, Area A
Wright-Patterson AFB, Ohio

Phone extension 55216
1. What is your present rank or civil service rating?  

2. What is your present job title?  

3. Are you actively engaged in data systems as an:  
   Check only one
   - (Digital Computer) Systems Analyst  
   - (Digital Computer) Systems Specialist  
   - Supervisory (Digital Computer) Systems Analyst  
   - (Digital Computer) Programmer  
   - (Digital Computer) Lead Programmer  
   - User or "Purchaser"  
   - Other (Please Specify)  

4. What are two most stimulating professional books you have read in the past two years?  
   1.  
   2.  
   Enter Total

5. What periodicals do you read regularly? (Enter Number in space)

6. Approximately how many professional meetings, other than local organizations, do you average attending each year? Enter Total

7. Of what professional organizations are you a member?  
   - System and Procedures Association  
   - The Institute of Management Sciences  
   - Data Processing Management Association  
   - Association of Computing Machinery  
   - Other (Please Specify)  
   Enter Total
8. Was the History of Computers time well spent?  

9. Did the explanation of the binary system and character representation help you to understand how a computer works?  

10. Did the presentation on computer hardware provide you with a basic understanding of computer hardware?  

11. Did you gain a useful understanding of computer software such as COBOL, Report Generators, Automatic Programming?  

12. In the computer hardware and software presentations, examples of the relationship between systems design and the effective use of computers were discussed. Were these examples useful?  

One such example was a quote from Secretary Morris concerning the Air Force Inventory annual turnover.  

36% of the inventory had no requisitions  
24% of the inventory had only 1-10 reqs/yr  
25% of the inventory had from 11-100 reqs/yr  
15% of the inventory had more than 100 reqs/yr  

Knowing this, we continue to store and manipulate data for the entire inventory and ignore more effective and efficient data search techniques.  

13. Has Optner's Module (Input-Processor-Output-Control-Feedback) been useful in your work?  

14. Has Optner's classification of systems as structured provided some insights to the problem areas in systems.
15. Were the lectures on the realities of systems enlighting regarding:

1) Lack of theory
2) Lack of standard definitions
3) Spillover or side effects
4) Defining the boundaries
5) Internal balance of capacity
6) External balance of capacity
7) Computer complex
8) Systems criteria - a management responsibility

16. Was the material on control in the systems useful? Yes No ?

i.e., Types of Control: Totals, "sums", hash, limit checks, self checking numbers, zero balancing, sequence check, feedback controls, and edit routines.

17. Was the discussion on preparing/planning for a systems study

Good
Useful

18. Was the grid charting technique as a tool for representation of the system

Interesting
Useful
Time well spent

19. How many times have you used the grid charting technique?

0 1 2 3 4 5 More than 5

20. If you have used the technique, answer the following:

1. Briefly state the name(s) of the Data System(s) - DSAP NUMBER
2. Did the grid charting technique facilitate:
   Your analysis Yes No
   Your design Yes No

3. Was it necessary to modify the technique? Yes No

4. Do you consider the technique?
   Useful Yes No
   Worth the effort Yes No

5. What Logistic Functions were involved in the Data System grid charted? (Circle no more than 3)

   Personnel
   Comptroller
   Plans
   Operations
   Procurement/Production
   Supply
   Maintenance
   Transportation

6. Did your grid charts display relationships between Reports and/or Documents to related Management Functions
   Data Elements
   Yes No
   Yes No

21. If you have not used the grid charting technique, identify the reason: (Check one only)

   1. No opportunity to use the technique
   2. Requested or directed not to use the technique
   3. Other - If other, please state the reason [ ]
22. How many times have you used the decision tables or tabular analysis?  
0 1 2 3 4 5  More than 5

23. If you have used decision tables, answer the following:

1. Briefly state the name(s) the system(s):

2. Did the use of decision tables facilitate your Analysis Yes No ?  
   Design Yes No ?

3. Was it necessary to modify the technique? Yes No ?

4. Do you consider the technique useful Yes No ?  
   Worth the effort Yes No ?

24. If you have not used decision tables, identify the reason: (Check one only)

1. No opportunity to use
2. Requested or directed not to use
3. Other

25. Of what value have the following phases of your system training at the School of Systems and Logistics been in your professional work?

1. Defining Systems Much Some Little None
2. Establishing boundaries Much Some Little None
3. Spillover effects Much Some Little None
4. Flow Charting Much Some Little None
5. Grid charting Much Some Little None
26. To what extent has your training at the School of Systems and Logistics contributed to the following?

1. **Professional skills**
   - Much
   - Some
   - Little
   - None

2. **Broader conception of systems**
   - Much
   - Some
   - Little
   - None

3. **Ability to do independent thinking**
   - Much
   - Some
   - Little
   - None

4. **Personal growth**
   - Much
   - Some
   - Little
   - None

5. **A more liberal point of view**
   - Much
   - Some
   - Little
   - None

6. **Ability to project thinking into larger systems**
   - Much
   - Some
   - Little
   - None
APPENDIX F

TABLE 29

Distribution of the Questionnaire Respondents

<table>
<thead>
<tr>
<th>Position Title</th>
<th>Class Roster</th>
<th>Questionnaire</th>
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</thead>
<tbody>
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<td></td>
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<td>%</td>
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<tr>
<td>1. Analysts</td>
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<td>59</td>
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<tr>
<td>2. Specialist</td>
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<td>3. Supervisor</td>
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<td>4. Programmer</td>
<td>36</td>
<td>16</td>
</tr>
<tr>
<td>5. Lead Programmer</td>
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<td>4</td>
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<tr>
<td>6. User</td>
<td>43</td>
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</tr>
<tr>
<td>7. Other</td>
<td>30</td>
<td>13</td>
</tr>
<tr>
<td>TOTAL</td>
<td>226</td>
<td>100</td>
</tr>
</tbody>
</table>

In compiling data from the class rosters, student identification as analyst or specialist was not possible because all these students were listed as analysts in the class rosters. The same was true for the user and other categories.
APPENDIX C

MCBOI 500-11

MCB OFFICE INSTRUCTION
NO. 500-11

DIRECTORATE OF DATA SYSTEMS
NO. ATR FORCE LOGISTICS COMMAND
Wright-Patterson Air Force Base, Ohio
13 November 1961

*SYSTEMS DESIGN TOOLS AND TECHNIQUES

PURPOSE: Contains the procedures to be used in the gathering and recording of data when conducting a feasibility study and developing a data system.

1. APPLICABILITY. To all personnel within the Directorate of Data Systems (MCR) who are involved in the design, development and implementation of data systems or are concerned in any other manner with data systems.

2. POLICY. The tools and techniques prescribed by this Instruction will be utilized when conducting a feasibility study and developing a data system.

3. RESPONSIBILITIES:

   a. The Office of Primary Development Interest (OPDI), upon assignment of a feasibility study or a development project, will designate a Data System Project Office (DSPO) to accomplish the appropriate action.

   b. The DSPO will record the data gathered, using the forms prescribed by this Instruction.

   c. The Office(s) of Collateral Development Interest (OCIDI) will contribute functional and technical knowledge to the OPDI as required for the area for which it has organizational responsibility.

*To expedite initial publication of this Instruction additional tools and techniques will be published in appendices as soon as they are developed.

OPI: MCBP

DISTRIBUTION: X: MCB 6 MCBP 6
MCBA 6 MCBR 8
MCBB 4 MCBW 8
MCFB 6 MCWAC 1
AF-IP-o-JUL 62 500 MCB1 6 MCGSP 1
4. PROCEDURES. Upon assignment of a feasibility study or a data system development project, the DSPO will gather all data pertinent to the assignment. This data may be gathered by interview with personnel of the Office of Prime and Collateral Policy Interest (OPPI and OCPI), by review of prescribing directives, etc. As the data is gathered, it will be recorded or charted as prescribed by the attachments to this Instruction. Evaluation of the data should be guided but not restricted by the prescribing directives.

FOR THE DIRECTOR:

O. C. ESTES
Major, USAF
Executive
Directorate of Data Systems

4 Attachments
1. Instructions for MCB Form 47 (revised)
2. Instructions for MCB Form 46 (revised)
3. Instructions for MCB Form 80 (proposed)
4. Instructions for Flow Charting
INSTRUCTIONS FOR USE OF MCB FORM 47 (REVISED)

1. The purpose of this form is to identify each document and file, and to reflect its relation with other documents and files. The first section identifies the document (file) by number, title, type code, prescribing directive, responsible office, etc. The second section identifies by number, title, type code and prescribing directive those documents (files) related to the document (file) of Section 1.

2. The terms "form number," "document/file title" and "Document code" are not restricted to a paper copy of the document, file, form, etc., but are to include records, files, etc., that are on the various kinds of tapes (magnetic, paper, etc.) and punch cards used by the system under study.

3. A copy of the form (or tape format) of the document or file must be attached to the Form 47.

4. SECTION I - IDENTIFICATION:

   Block A - Form Number - enter the DON, AF, AFLC, etc., form number. In the case of EDPM products, this could be the tape file identification from which the form or reports is produced.

   Block B - Document/File Title - enter the official title of the attached document.

   Block C - Doc Code (Document Code) - enter the appropriate mnemonic code (S,B,I,R) which identifies the type of document being studied. (If two or more codes are applicable, enter all of them.) Explanation of codes is at the bottom of Form 47.

   Block D - Prescribing Directive - enter the paragraph, section, chapter and number of the directive which prescribes the use of this document/file.

   Block E. - Responsible Office - enter the office responsible for the prescribing directive.

   Block F - Number of Copies - indicate whether single, duplicate, triplicate, quadruplicate, etc.

   Block G - Frequency - indicate if this form is used, or produced, in a daily, weekly, monthly, etc., processing. (Use codes indicated at bottom of form.)

   Block H - Volume - enter an estimate of the number of these documents that are processed, or produced, during each frequency period.
Block I - Distribution - Enter the organization codes of the recipients of this product.

Block J - Source Organization Code - Enter the organization code of the unit from which the document is received.

Block K - Processing Organization Code - Enter the organization code of the unit which processes the document. If multiple organizations process the form, individual sheets (Form 47) will be prepared for each organization.

5. Section II - BACK-UP DATA:

   This section contains a brief summarization of the relationship between the document (file) identified in Blocks A & B and other document (files) in the system under study.

   Column 1 - Form Number - Enter in this column the DOD, AF, AFLC, etc., form number, for each document/file that is directly related (in processing) to the document identified in Block A.

   Column 2 - Document/File Title - for each entry in column 1, enter the title.

   Column 3 - Doc Code - for each entry in Column 1, enter the mnemonic code which identifies the type of document in relation to the form (title) under study. (Codes at bottom of Form 47.)

   Column 4 - Prescribing Directive - for each entry in Column 1, enter the paragraph, section, chapter and number of the directive prescribing the use of this document (or file).

   Column 5 - Remarks - enter any pertinent remarks concerning each entry in this section in relation to the form under consideration.
### Section I - Identification

<table>
<thead>
<tr>
<th>A. Form No.</th>
<th>B. Document File Title</th>
<th>C. Doc Code</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>D. Prescribing Directive</th>
<th>E. Responsible OPC</th>
<th>F. No. of Copies</th>
<th>G. Frequency</th>
<th>H. Volume</th>
<th>I. Distribution</th>
</tr>
</thead>
</table>

|-----------------------------|---------------------------------|

### Section II - Back-Up Data

<table>
<thead>
<tr>
<th>Form Number</th>
<th>Document File Title</th>
<th>Doc Code</th>
<th>Prescribing Directive</th>
<th>Remarks</th>
</tr>
</thead>
</table>

**Document Code:**
- S: Source Document (Initial Input)
- T: Task Code
- I: Intermediate File
- R: Report

**Frequency Code:**
- AR: As Required
- M: Monthly
- Q: Quarterly
- D: Daily
- S: Semi-Annual
- A: Annual
- W: Weekly
- X: Other (Identify)
INSTRUCTIONS FOR USE OF MCB FORM 46 GRID CHART WORKSHEET (REVISED)

1. This form is to be used in studying and evaluating the relation between documents (files) within a system or segment of a system.

2. Completing the Form:

   a. Major Area - Identify the area in which documents are used. (Supply, Maintenance, etc.; or IM system, ARLS, etc.)

   b. Sub-Area - Identify that portion of the major area which is applicable.

   c. Organization - Enter the organizational code of either area (a or b above).

   d. Frequency - for each document (file) identified, enter the frequency of occurrence (using the codes at the bottom of the page).

   e. Document Code - Identify the type of document (file) (using the codes described at the bottom of the form; no other codes will be used. If two codes apply, make a columnar entry for each. Source (S) Documents cannot appear as columnar headings and Reports (R) cannot appear as line entries.

   f. Column Headings - Enter the document (file), identify by title or number for each product.

   g. Line Entries - Enter the document (file), identify by title or number for each input item.

   h. Enter x's in the grid to reflect the relation of the inputs to the outputs.

3. Evaluating the Completed Form:

   a. Evaluation of the entries should include, but not be limited to, the following:

      (1) How many documents (files) serve both as

         (a) Basic Records (B's) and Source Documents (S's)?

         (b) Basic Records (B's) and Reports (R's)?

      (2) Identify the documents (files) of (1) above.

Attachment 2 (Continued)
(3) Are there other documents (files) which have dual functions? (i.e., such as the Basic Records (B's) and Intermediate (I's) files; S's and R's, I's and R's; I's and S's).

(4) Identify the documents (files) of (3) above.

(5) What is the impact of these combinations? Are they correct?

(6) Are the documents properly coded?

(7) Do two (or more) documents (files) serve the same purpose?

(8) Study the frequency of related documents (files). Are they consistent?
<table>
<thead>
<tr>
<th>DOCUMENT CODE</th>
<th>EDR PRODUCTS (Note Processing/Postprocessing)</th>
</tr>
</thead>
<tbody>
<tr>
<td>INPUT DOCUMENTS</td>
<td></td>
</tr>
</tbody>
</table>

**FREQUENCY CODE**

- **AR** - As Required
- **M** - Monthly
- **Q** - Quarterly
- **D** - Daily
- **S** - Semi-Annual
- **A** - Annual
- **W** - Weekly
- **X** - Other (Identify)
1. GENERAL:

   a. This form will contain data that is required at various stages of analyzing, developing and documenting data systems. It has been designed, therefore, to serve as:

      (1) A means of collecting and recording elements of data in their relationship to the documents of a system. (See 2 below.)

      (2) A means of depicting the file-element relationship between the inputs and outputs of functional areas (and runs) of a system. (See 5 below.)

      (3) A means of providing a complete listing of all the elements of data in a system and the input and output documents on which they appear. (See 6 below.)

   b. This form can be utilized most efficiently by identifying and entering all the elements for one document before entering the identity of the elements on subsequent documents.

   c. The completed MCB Form 80 will be evaluated in terms of identifying non-standard data elements (see 4 below) and determining proper relationship between documents, files and elements, including duplication, omission and conflict.

2. FACT GATHERING - DATA ELEMENTS AND CODES:

   a. The identification of the Data Elements and Codes involved in any new system or revision or redesign of the current system falls basically into two phases.

   b. The information originally required on each element or code is the name, structure (field length and alpha/numeric characteristics) and the document, or form on which it appears.

   c. Phase No. 1 - All input/output documents (or forms) related to the system being designed must be thoroughly screened and those elements or codes contained therein extracted. These elements should be recorded on MCB Form 80.

   d. Phase No. 2 - The objectives and goals of the new system must be thoroughly reviewed to determine, or develop any new elements or codes which may be required in addition to those previously recorded in Phase 1. These additional elements or codes must be added to the basic list but separately identified as to the document in which they will appear.
A sample copy of each document (input/output) will be attached to MCB Form 47.

3. COMPLETION OF FORM:

   a. Block 1 - System/Process Identification - Enter the system title (or process number) for which the elements of data and the documents are to be recorded.

   b. Blocks 2 & 4 - Title, or form numbers, are entered as column headings for both inputs and outputs.

   c. Blocks 3, A, B, C - List all elements for each and every input and output document by element name, number (i.e., the DEN, Data Element Number) and structure, or name and structure if the element has not been standardized.

      (1) (Start with inputs.) List all elements for one document at a time, and enter an "x" in the appropriate column.

      (2) For subsequent input documents, enter only the "x" if the element name has been previously entered. (This should only happen if the element fits the standard description.)

      (3) Enter an "x" for each output document which will contain the element as described.

      (4) If the element appears more than once on a document (or file), enter the number (of appearances) rather than an "x".

4. DATA ELEMENTS AND CODES

   a. MCB Form 80 prepared on data elements and codes will be evaluated and appropriate action taken in consideration of the following:

      (1) Check each individual element or code against those published in AFLCM 500-2 to insure that they agree both in name and structure and the correct Data Element Number (DEN) has been assigned. Insure that elements of the same name mean exactly the same thing.

      (2) Analyze the balance of the elements or codes for similarity to any published in AFLCM 500-2 and if determined to be identical, coordinate with the OPPJ the change of name or structure to that shown in AFLCM 500-2 and add the DEN to the chart.
(3) The remaining elements or codes not yet resolved or showing a DEN should be reviewed to determine those that have the same meaning and serve the same intent. These should be analyzed and the preferred name and structure determined prior to submission for standardization. MCB Form 80 must now be corrected to reflect this consolidation by entering and relating the preferred name, structure and associated document, then deleting each of those elements that it replaces.

b. Upon conclusion of this evaluation and analysis of the grid chart, an MCB Form 1 should be prepared in accordance with MCBOI 500-1 on those elements and codes which do not have an entry in the DEN column on MCB Form 80. Completed MCB Forms 1 are to be forwarded to MCBP for approval for use and standardization action as specified in MCBOI 500-1. The Directive number can be obtained from the sample copies attached to MCB Form 47 during the "Fact Gathering" and the definition can be extracted from this directive, for inclusion on the MCB Form 1.

5. Interrelation of elements and Input and Output Files between sub-systems and runs:

a. Data elements passing between systems (subsystems), runs, etc., should be thoroughly screened to insure that an element described as output is the element required, and expected, as the subsequent input.

b. MCB Form 80 will be prepared by each system analyst and programmer as applicable, to affect this integration of data.

c. Completed MCB Form 80 will be reviewed and checked to insure the compatibility of description of output vs input.

6. SPECIFICATION STANDARDS - DATA ELEMENTS AND CODES:

a. MCB Form 80 will serve as the official listing of all the Data Elements and Codes to be included in the system being designed. Thus, the completed form should be duplicated to serve as the statement of the inputs and the outputs for the System Design Specification. A copy of this completed form will ultimately appear in the 500- series manual for the system as the means of listing all documents and elements pertinent to the system.
BOOKS


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**Articles and Periodicals**

Baker, Alton W. and Davis, Ralph C. *Ratios of Staff to Line Employees and Stages of Differentiation of Staff Functions*. Columbus, Ohio: The Ohio State University Bureau of Business Research, 1954.


Reports


Unpublished Materials


Lieberman, Irving J., Senior Technical Staff of Litton Industries. An address to the Institute of Management Sciences, New York City, New York, October, 1955. (Typewritten)

Other Sources

McDonough, Adrian M. Lectures given at the School of Systems and Logistics since 1959.

Seim, Colonel H.B., Jr. A keynote address delivered to the first management conference of the Central State College Chapter of the Society for the Advancement of Management at Wilberforce, Ohio, on December 6, 1963.

Personal interviews conducted with 50 of the 226 respondents in this study.