

TIME-SHARED INFORMATION SYSTEMS
FOR PURCHASING

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This is to certify that the

thesis entitled

TIME-SHARED
INFORMATION SYSTEMS
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ROBERT MACK MONCZKA

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ABSTRACT

TIME-SHARED INFORMATION SYSTEMS FOR PURCHASING

By

Robert Mack Monczka

This study provides new information on the use of time-shared information systems for purchasing and materials management. A time-shared system is defined as "a communications-oriented method of using computers. It is a technique that permits concurrent utilization of the same installation by two or more persons working at remote devices capable of direct, on-line access to the data processing equipment."¹ Previously, only limited research information has been available regarding the use of time-shared systems for an important area of business, purchasing and materials management.

The hypothesis of this study was that time-shared information systems can contribute to purchasing performance by providing required information for improved decision-making. This was substantiated by field research with eight firms using or planning to use time-shared information systems.

Field research was also conducted with seven commercial time-sharing firms to obtain information regarding possible use of commercial systems for purchasing and materials management.

This study presented detailed information on: time-shared system operation; factors influencing the decision to use time-shared systems; reasons for internal or external systems; operational time-shared system descriptions, benefits, costs, development and operational changes; and commercial time-sharing service capabilities.

Major findings were classified by: (1) system applications, (2) design and development, (3) major changes, (4) computer systems, (5) future applications, and (6) commercial time-sharing.

System applications findings were: time-shared systems were developed for buying, inbound transportation, purchased parts and materials inventory control, receiving and receiving inspection, and production control applications. Improved purchasing-materials management performance was related to improved material and parts flow into and through the firm, improved capability to react quickly to problem situations, general administrative benefits and effects on personnel, and improved analytical capabilities. Time-shared system development was primarily related to a dynamic operating environment and a management philosophy favorable to computer-based information systems.

Design and development of time-shared purchasing-materials management systems required personnel knowledgeable in computer systems and functional operations, generally took from one to two years and was influenced by earlier investment in computer systems.

Major changes were: time-shared systems appeared to improve coordination between functions in purchasing-materials management; personnel were generally favorable to time-shared systems and preferred to use terminals over hard copy reports; and purchasing-materials management systems, procedures, and data bases were only appreciably changed when firms converted from manual systems to time-shared systems.

Third generation computer systems appeared able to support time-shared system operation and were operational more than 95 per cent of possible use time. Using firms had a significant investment in computer personnel and equipment.

Future applications of time-shared systems would possibly reduce report and operating document paperwork, change work patterns and further development of time-shared systems between buying and supplying firms.

Commercial time-sharing services could be used by purchasing and materials management departments. Installation of commercial systems for analytical applications appeared relatively easy. However, only a limited number of

commercial time-shared application programs were available for purchasing-materials management and the cost of storing data on-line often makes it more economical to purchase or lease a computer system for firms with large data files.

Conclusions of the research were: time-shared information systems have broad application potential in purchasing-materials management, use of both internal and commercial time-shared systems will probably increase, careful analysis is required to determine applications best suited for time-shared systems, time-shared systems could change the manner in which purchasing and materials management activities are completed, and additional analytical application programs will probably be developed.

¹James R. Ziegler, Time-Sharing Data Processing Systems (Englewood Cliffs, N. J.: Prentice-Hall, Inc., 1967), p. 10.

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Robert Mack Monczka

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CHAPTER I

OBJECTIVES, NEED, RESEARCH METHODS, LIMITATIONS OF STUDY

Introduction

The purpose of this study is to provide information on the use and applications of time-shared information systems for purchasing and materials management purposes. The study examines some of the newest advances in computer system development as they can be applied to purchasing and materials management activities.

The purchasing-materials management function is concerned with acquisition of necessary raw materials, component parts and services, and the management of this material flow to support manufacturing or other operations. It is a complex function and contributes significantly to the profitability of many firms. For example, a typical manufacturing company spends approximately 50 per cent of its sales dollar on purchased parts, materials, and services.¹ Also, the value of a firm's inventory commonly

¹Dean S. Ammer, Materials Management (Homewood, Ill.: Richard D. Irwin, Inc., 1968), p. 4.

varies from 15 to 24 per cent of its invested capital and the inventory carrying costs of a typical manufacturer range from 17 to 24 per cent of average inventory value.² Therefore, a company's profitability can be greatly influenced by decisions of purchasing-materials management personnel.

Further emphasizing the significant impact which purchasing-materials management has on individual firms and the economy, and the limited study done in the area is the statement by Professor John H. Hoagland:

Relatively little study has been done on the magnitude of industrial purchasing in this country, but it is estimated that the amount of industrial purchasing exceeds the gross national product. Currently, industrial purchasing is probably in excess of a trillion dollars annually. How and when industrial purchasing is done determines the business cycle activity in this country.³

In addition, purchasing-materials management decision-making is complex due to the many variable factors that require examination to provide parts, materials and services at the right time, place, and quality at the lowest total cost to the firm. For example, purchasing-materials management decision-makers are concerned with information related to prices, availability, transportation cost, transportation alternatives, production schedule requirements,

²Lamar Lee, Jr. and Donald W. Dobler, Purchasing and Materials Management (New York: McGraw-Hill Book Company, 1965), p. 186.

³John H. Hoagland, "Keys to Business Forecasting" (address before the Twelfth Annual International Conference of the American Production and Inventory Control Society, New York, Hilton Hotel, Nov. 6, 1969).

receiving status, quality inspection status, inventory levels, suppliers, usage forecasts and many other information categories.⁴

The complexity and the importance of this purchasing-materials management function places pressure on those responsible for it to develop information systems that provide timely, accurate, and adequate data on which to base decisions. In some cases, it is advantageous to use electronic computer systems for these purposes. Primary advantages of establishing and operating computer-based information systems are their ability to rapidly process large volumes of disaggregated data and produce detailed or summary information for planning and control.

Computer system development has progressed significantly from the first electronic digital computer installed which was the ENIAC at the University of Pennsylvania in 1946. This computer could do in one day what would have required 300 days to perform manually.⁵

⁴For additional examples of purchasing-materials management information needs, see, Harold E. Fearon and John H. Hoagland, Purchasing Research in American Industry (A.M.A. Research Study 58; New York: American Management Association, 1963), pp. 31-45.

⁵Donald H. Sanders, Computers in Business (New York: McGraw-Hill Book Company, 1968), p. 26.

Since the development of ENIAC, computer technology has advanced to the third generation of computers which are now greater than 900 times faster than computers in 1950.⁶

First, second, and third generation computers refer to stages in computer development. Major characteristics that are commonly used to distinguish between generations are electronic hardware components, logical organization, and software.

A first generation computer can be described in relative terms as being a vacuum-tube computer with slow operating capabilities and high electrical consumption requiring heavy-duty air conditioning. It had a high probability of malfunctioning and high maintenance costs. The logical construction was such that all operations were performed sequentially. Whenever input or output was occurring, no computations could be performed. The software generally consisted of a program loader and simple utility routines and a compiler. First generation computers reached their peak of use during the late 1950's and early 1960's.

The second generation was primarily characterized by replacement of vacuum tubes with transistors resulting in greater reliability, smaller physical size, and reduced electrical consumption and air conditioning requirements. It was also characterized by high speed magnetic core

⁶Ibid., p. 37.

memories and moderate capacity. Logical organization allowed input and output operations to occur simultaneously with computation and the interruption of the central processing unit (CPU) so that several operations could be performed at one time.

Software included an input/output control system (IOCS) thereby eliminating the necessity to repeat complex input/output logic in every program. An interrupt feature was also introduced. Second generation computers fostered the great growth of computer system use in the early and middle 1960's.

Third generation computers which utilized integrated circuits were first announced in 1964, and are characterized by continued improvements in:

Electronic equipment--use of integrated circuits meaning smaller, faster, cheaper, and more reliable computers.

Logical organization--the ability to handle many programs simultaneously, a hierarchy of storage devices to meet user requirements, modularity or the ability to change the computer system configuration to meet the circumstances and remote input/output by means of telecommunications.

Software--increased sophistication of the operating system which becomes absolutely necessary to

maintain the normal functioning of the computer, the common use of multiprogramming and the availability of conversational programming techniques.

Also, a computer system may be composed of first, second, and third generation characteristics. It becomes very difficult to place rigid boundaries between the systems. However, effort to distinguish is useful for pointing to general trends and description of a firm's operating computer systems.⁷

Time-Shared Systems

The recent development of time-shared computer systems in the middle 1960's has introduced additional considerations in information systems design in the purchasing-materials management area.⁸ Time-sharing

is a communications-oriented method of using computers. It is a technique that permits concurrent utilization of the same installation by two or more persons working at remote devices capable of direct, on-line access to the data processing equipment. Each of the users of a time-sharing system must have the ability to inquire into and add to or alter information in files accessible to the data processing installation in random access fashion, on demand.⁹

⁷Philip B. Jordain, Condensed Computer Encyclopedia (New York: McGraw-Hill Book Company, 1969), pp. 525-529.

⁸Sanders, Computers in Business, p. 47.

⁹James R. Ziegler, Time-Sharing Data Processing Systems (Englewood Cliffs, N. J.: Prentice-Hall, Inc., 1967), p. 10.

Also, computer information systems which meet all requirements of this definition except the ability to add to or alter files immediately through remote devices must be examined in systems design. These systems are defined as time-share oriented in the study.¹⁰

Questions of real-time management, direct-access information retrieval, benefits of time-shared information systems and their applications potential are often topics of discussion as can be seen in the literature. Purchasing-materials management executives are also interested in these types of systems as evidenced by discussions with these people.

Information related to the development and operation of time-shared information systems in purchasing-materials management will provide a basis for decisions to implement new or change current information systems design.

The importance of purchasing-materials management to the firm and to the economy, the limited study done in this area and the recent developments in computer information systems, all support the need for a study such as this.

¹⁰The term "time-shared system" will, in the remainder of this study, include the defined meaning for "time-share oriented system" unless explicitly stated otherwise. This convention improves the writing style.

Definition of Terminology Used in Study

Terminology uses in the study are defined in the following paragraphs:

Purchasing will include the activities of buying, inbound transportation, receiving, receiving inspection, and purchased parts and materials inventory control.

Materials management will, in addition, include production scheduling or control.

Data is defined as unorganized elements or facts pertaining to an activity while information has been or organized in some form to satisfy a need. A data base contains stored data which are available for computer processing with various application programs. A file is a collection of related records treated as a unit.¹¹

A computer-based information system has the ability to process or organize data through computer utilization and present the information as specified. The term information system will imply a computer-based information system unless otherwise noted.

Time-shared systems are associated with on-line, random access, real-time capabilities. An on-line system has equipment engaged and functioning with the central processing unit, including point of origin devices "such as control consoles, input keyboards, meters and other

¹¹Jordain, Condensed Computer Encyclopedia, p. 212.

instruments capable of sending machine sensible signals, which are connected directly to the central processor and are used to address a program in memory or storage."¹²

Random access "describes a process in which data is accessed in nonsequential order and possibly at irregular intervals of time."¹³ Examples of random access devices are drum and disk storage units.

A real-time system is defined as one where data is maintained on-line and is updated as events occur with computer interrogation capability from remote terminals.¹⁴ Furthermore, any system referred to as real-time oriented will correspond to a real-time system except that data update will not occur as events happen, but will take place at a later time related to an imposed deadline that is of significance to the user of the information.

Hardware is defined as the tangible, physical components of a computer system.¹⁵ Software is programs and routines that can be used on a particular type of computer.¹⁶

¹²Michael E. Shays, "The Feasibility of Real Time Data Processing," Management Services, II (July-August, 1965), 20.

¹³Jordain, Condensed Computer Encyclopedia, p. 414.

¹⁴John Dearden, "Myth of Real-Time Management Information," Harvard Business Review, ILIV (May-June, 1966), 124.

¹⁵Jordain, Condensed Computer Encyclopedia, p. 234.

¹⁶Ibid., p. 477.

A terminal is used when data transmission is involved and refers to some device with input or output capability and electronics that interfaces with the rest of the system.¹⁷ An example of one type of terminal is a cathode-ray tube display (CRT).

The decision-making process will be viewed as existing of the following elements:

1. A triggering or forcing function which initiates the decision process.
2. Decision criteria which provide the basis for response to given stimuli.
3. Decision rules which provide formalized response as a function of variable input.
4. Action actually taken as a result of the decision process.
5. Outcome or result of the actions on system performance.
6. Feedback to correct decision criteria or decision rules.¹⁸

This process model recognizes that varying aspects of information flow through any area of the organization can act as a triggering mechanism initializing a decision process. The information is at least a partial basis for selection of a response and also provides the mechanism for feedback and evaluation of the action taken. Timeliness and adequacy of information is of prime importance in a

¹⁷Ibid., p. 523.

¹⁸Alan J. Rowe, "Management Decision Making and the Computer," Decision Theory and Information Systems, ed. by William T. Greenwood (Cincinnati: Southwestern Publishing Company, 1969), p. 751.

functioning organization and systems providing this information are significant to operation of the firm.

Need for Study

The use of time-shared information systems and possible real-time operation is an area of increasing analysis and discussion.¹⁹ The initial approach, by airline and stock-brokerage firms, to development of these types of information systems has proven worthwhile in helping to solve operating problems of these industries.²⁰ Management continues to discuss development of time-shared systems using a company-wide data base for decision-making. Furthermore, trade publications occasionally include articles describing such systems.

However, a relatively small amount of research based information is available regarding time-shared information systems. Furthermore, published research studies on these types of information systems for purchasing-materials management use were not found in a literature review.

¹⁹See, for example, James R. Ziegler, "How to Prepare for Time-Sharing," Business Automation, XV (January, 1968), 46-50; William M. Zani, "Real-Time Information Systems: A Comparative Economic Analysis," Management Science-Applications, XVI (February, 1970), B350-B355; Robert V. Head, "Planning for Real-Time Business Systems," Journal of Systems Management, XVIII (July-August, 1967), 10-17; "Litton's Electronic Information Machine," Business Week, MMCXVII (March 28, 1970), 158-162.

²⁰Lawrence L. Lipperman, Advanced Business Systems (New York: American Management Association, AMA Research Study 86, 1968), p. 61.

The complexity and changing nature of the interacting variables in purchasing and materials management make the area a logical candidate for design and implementation of time-shared systems. Research on the use of these systems for purchasing-materials management could help organizations reduce their purchasing-materials management costs which could have considerable impact on a firm's profitability. Additional information would also be available to those studying time-shared information systems.

Furthermore, little has been published regarding capabilities of the commercial time-sharing service industry to provide purchasing and materials management departments with reliable computing and information systems. A survey of firms in the commercial time-sharing industry regarding current and future capabilities could also prove valuable to many organizations.

Information presented in this study should advance purchasing and materials management knowledge of time-shared information system development, use, and potential.

Hypothesis

The hypothesis of this study is that time-shared information systems can contribute to purchasing performance by providing required information for improved decision-making.

To substantiate the hypothesis, a number of factors are examined. Major factors are: reasons for time-shared

system development, applications, benefits, cost factors, and major changes encountered by using firms.

Objectives

The purpose of this study is to develop supportable conclusions based on field research regarding contributions to improved performance that can be made by time-shared information systems for purchasing. In order to test the hypothesis and further develop knowledge of purchasing and materials management information systems, information obtained from the research will be presented on the following:

1. General hardware and equipment required for time-shared computer operation.
2. Major considerations time-shared system users should be aware of.
3. Major factors influencing the decision to utilize a time-shared system.
4. Reasons for developing systems on an internal basis or using commercial time-sharing capabilities.
5. Time-shared information systems observed.
6. Time-shared system applications.
7. Synopsis of major data and information input/output classifications.
8. Contributions to purchasing performance based on user criteria.
9. Cost factors.

10. Major changes encountered in system design, implementation and operation related to:
 - a. Data base development.
 - b. User operating programs.
 - c. Computer system conversion effects on purchasing systems and procedures.
 - d. Personnel and organization effects.
11. Commercial time-sharing firms survey:
 - a. Availability of purchasing and materials management application programs.
 - b. Pricing structure.
 - c. Major considerations for users.
 - d. Future time-sharing application program trends.

Research Methods

Included in the research was a literature survey of books, articles, monographs, and literature from computer manufacturers, peripheral equipment manufacturers and commercial time-sharing firms. The objectives of this review were to gain additional knowledge of the hardware used in time-shared systems and develop a framework regarding implications of using time-shared information systems for purchasing and materials management.

Field research was then initialized and completed during the period from January, 1970, to May, 1970. The field research included visits to seven commercial time-

sharing firms, two computer manufacturers, a data communications firm, and eight firms using or planning to use time-shared information systems for purchasing and materials management purposes. One company visit included four divisions, each with individual purchasing or materials management responsibility, thereby increasing the time-shared system users sample to eleven. Eight of the eleven were using time-shared systems and three were in the planning stage.

Visits to these organizations varied from one-half day to three days. Interviews were conducted using the interview guides in Appendices A and B to ensure coverage of points of interest. The interview guides were sent to participating firms prior to the visit. This allowed individuals involved time to develop their thinking regarding subjects to be discussed.

Generally, the individuals interviewed at using firms were from both the systems and purchasing-materials management functions. Interviewees at commercial time-sharing firms were systems representatives and systems analysts.

Interviews at using firms included all levels of purchasing and materials management personnel, from directors of purchasing to buyers, which allowed for various information system perspectives. Furthermore, pertinent documents, organization charts, feasibility studies, and other formalized information were obtained where possible.

The using firms included in the field research phase of the study were advanced information system users for purchasing and materials management purposes. Contacts were developed through relationship of the dissertation committee chairman with purchasing and materials management executives of leading firms and through discussions at Michigan State University-National Association of Purchasing Management seminars over the past two and one-half years.

This was not intended to be a random sample because of the relative newness of time-shared system applications for purchasing and materials management. The firms included would have to be placed at the forefront of time-shared system development. Only the first steps have been taken to develop and implement these systems. It should also be noted that there were additional firms working in this area which were not included in the study because of time and resource limitations.

The purpose of the interviews was to obtain detailed data regarding design, development, and operation of time-shared systems. The interview environment allowed instantaneous reaction to comments and information, therefore leading to additional information. It also ensured establishment of a common understanding between interviewer and interviewee in discussion areas.

Limitations of the Study

1. Interview Sample: No attempt was made to establish a random sample of firms to be included in the study. Therefore, all inferences of the reader related to the general population of purchasing and materials management departments should be carefully considered.
2. Confidential Nature of Data: Information on a specific company's purchasing and materials management information systems and procedures could not be as complete as the reader may desire due to the confidentiality of data. Also, identity of the companies participating is not disclosed except for the University of Illinois which operates on a non-profit basis.
3. Evaluation of Computer Hardware: No attempt has been made to evaluate specific technical operating characteristics of computer hardware used in the time-shared systems studied.
4. Cost/Benefit Analysis: Complete cost/benefit analysis for systems under study was not possible. This was due to the hesitancy of some firms to make available such information or the lack of information in the firm.
5. Behavioral Considerations: No attempt has been made to specifically examine behavioral aspects related to direct man-machine interface systems.

Organization of the Study

This study is organized into six chapters:

Chapter I introduces the study environment and defines important terminology. The need for the study is discussed and the hypothesis and objectives are presented. Research methodology is explained and limitations of the study are noted.

Chapter II is a summary of the literature reviewed concerning computer-based information systems. It includes discussion of general information systems and purchasing-materials management information systems. Also, time-sharing is examined as are implications related to on-line, real-time types of systems with a man-machine interface.

Chapter III discusses the results of the field research and develops a purchasing and materials management information system classification model. The chapter also describes time-shared system configurations and purchasing and materials management applications with a synopsis of major data and information input/output classification categories. Also noted is analytical work being done on time-shared systems.

Chapter IV discusses and analyzes additional research findings of the study primarily concerned with major developmental consideration variables, contributions of time-shared systems, related cost factors, and major changes associated with time-shared systems for purchasing and materials management.

Chapter V presents and analyzes current and future trends in the commercial time-sharing industry for consideration by purchasing and materials management personnel examining the possible use of these services. Application program availability, pricing structure, major user considerations, and future trends are discussed.

Chapter VI interrelates the research findings to draw conclusions regarding the use of time-shared information systems for purchasing and materials management, both on an internal basis or through utilization of commercial time-sharing firms.

CHAPTER II

LITERATURE ON COMPUTER-BASED INFORMATION SYSTEMS AND COMPUTER-BASED PURCHASING INFORMATION SYSTEMS

Introduction

A review of the literature was undertaken in an attempt to determine and document concepts, problems and courses of action considered important to computer-based information systems, to time-shared information systems and to their use for purchasing and materials management.

The review consisted of an examination of periodicals, books and monographs primarily published since 1965. Publications of the last five years were more significant to time-shared systems because major use of these systems corresponded to the development of third-generation computers in the middle 1960's. In addition, a less extensive review included publications of the last ten years which appeared to be of major significance.

As the literature review progressed, it became obvious that a report of the results would have to be limited due to the extensive quantity and coverage of topics

in available publications.¹ Therefore, selection of major areas for discussion was restricted to considerations most directly related to the objectives of this study. These areas were:

1. Computer-based information systems.
2. Time-shared systems.
3. Interactive nature of time-shared information systems.
4. Purchasing information systems.

Figure 1 indicates the basic approach to the literature review.

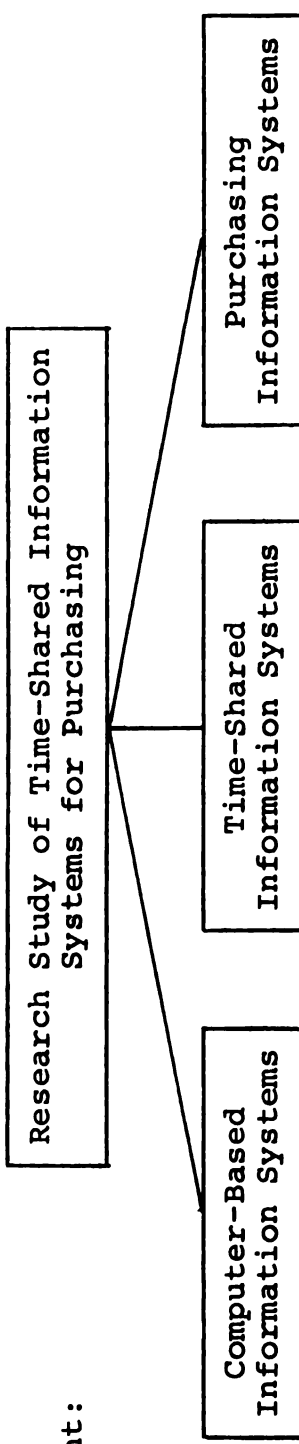
Computer-Based Information Systems

The results of the literature review related to information systems in general will be discussed as they pertain to the following topics:

1. A planning and control framework.
2. Need for computer-based information systems.
3. General impact of information systems in business, functional implementation and applications.
4. Factors relating to successful and unsuccessful information systems.
5. Information systems for planning and control.

¹See, J. Daniel Couger, Computing Newsletter for Schools of Business, III (January, 1970).

State-of-the-Art Advancement:



Literature Review:

- Planning and control and information needs
- Need for C-B I-S
- Current applications and functional area development
- System capabilities
- Future emphasis and impact on planning and control
- Factors related to successful information systems

Basic Concepts:

- Time-shared system configuration and operations
- Time consideration of on-line real-time systems
- Planning and control implications
- Interactive nature of the system
- Changing problems

- Review of batch processing purchasing applications for planning and control purposes
- Initial time-shared system applications
- Facts related to specific time-shared cases.

FIGURE I

Time-Shared Information Systems for Purchasing Purposes: An Approach to Literature Review

Planning and Control Framework

The Anthony approach to analysis of planning and control provided a useful framework for categorizing types of information required and is widely used. Anthony writes that planning and control exist at all levels in the organizational hierarchy but that planning emphasis is pre-dominant at the higher levels while control emphasis is predominant at the lower levels.² This varied emphasis will influence the information that regularly is provided personnel at different organizational levels.

Definitions of the planning and control categories were:

"strategic planning is the process of deciding on objectives of the organization, or changes in these objectives, on the resources used to attain these objectives, and on the policies that are to govern the acquisition, use and disposition of these resources."³

"management control is the process by which managers assure that resources are obtained and used effectively and efficiently in the accomplishment of the organizations objectives."⁴

²Robert N. Anthony, Planning and Control Systems: A Framework for Analysis (Boston: Division of Research, Graduate School of Business Administration, Harvard University, 1965), pp. 15-19.

³Ibid., p. 16.

⁴Ibid., p. 17.

"operational control is the process of assuring that specific tasks are carried out effectively and efficiently."⁵

These planning and control categories which can be associated with different levels of the organizational hierarchy suggest that regular information requirements vary by level in the organization. Information system design should provide for these distinctions.

Strategic planning will generally require aggregate activity and significant external information. It will also include information only indirectly associated with operating task activities such as personnel and capital equipment availabilities and capabilities. Decision-making at the strategic planning level will take place in an unstructured framework which reduces the ability to define all information needs.

Management control requirements are more oriented to operating activities and decision-making takes place in a more structured environment than in strategic planning. Lower levels of aggregated activity information is required to assure achievement of objectives.

Operational control information is primarily related to tasks carried out by a firm. For example, purchase requisition issuance, purchase order placement,

⁵Ibid., p. 18.

material receipt, material inspection and inventory adjustment are tasks or activities in the materials management cycle. Data inputs reflecting task performance and the resulting information is primarily used for operational control decisions.

Strategic planning implications of task information cannot be ignored, though, especially at critical problem times. For example, when strike threats occur at supplier plants, detailed activity information is required at higher levels in an organization. This does not hinder the general usefulness of the framework but should be recognized.

Anthony further writes that time considerations were also important to information need analysis related to computer-based information systems. Strategic planning will generally focus on future implications of available information. Management and operational control, with a shorter relevant time interval, will place more emphasis on past and immediate aspects of the situation. This may indicate the need for more current information in management and operational control than in strategic planning.

Need for Computer-Based Information Systems

Pressure for continued advancement of computer-based information systems is primarily due to the increasing complexity of business and the need to quickly react to changing conditions in the environment. According to Hodge and Hodgson:

If only we had the capacity to forecast the future accurately, there would be little need for the complex information systems which are now under development by most companies. We do not. Therefore, our information systems must allow us to recognize deviations from plan at the earliest possible moment and be able to react rapidly in as near an optimum manner as possible. A major reason for the development of sophisticated management information systems is a recognition of the dynamic nature of business activities combined with recently acquired ability to react rapidly to changes.⁶

In Computers and Management--The Letherbee

Lectures, it was stated that:

. . . Computers have steadily assumed a more useful role, from a managerial point of view, as information purveyors. In the past, they have been used to relieve the intolerable clerical burden, for example, of (1) increasing informational reports and analysis needed by management to do profitable business in a world of growing complexity and increasing speed of change and (2) increasing government regulations and requirements for reports for tax, social security, SEC, and other purposes.⁷

An example of an advanced computer-based information system currently in use was given by Litton Industries. They have recently implemented an information system which provides access to eight day old data which contrasts to forty-five day old data at some large companies. Their information is available to management regarding 225 profit centers. The information is required because:

⁶Bartow Hodge and Robert N. Hodgson, Management and the Computer in Information and Control Systems (New York: McGraw-Hill Book Company, 1969), p. 224.

⁷Computers and Management--The Letherbee Lectures (Boston: Graduate School of Business Administration, Harvard University, 1967), p. 4.

. . . as with its fellow conglomerates, Litton is hard pressed to keep track of all its pieces. The company's world-wide empire encompasses roughly 10,000 products, ranging from spinach souffle to warships, produced by 120 operating divisions that divide into nine groups.⁸

Further support for development of computer-based systems was based on their ability to automatically prepare many documents from basic activity data and eliminate the need for manual preparation. Examples are computer printed sales orders, invoices, purchase orders and receiving documents.

General Impact of Information
Systems, Functional Implemen-
tation and Applications

Numerous reasons exist for development and extensive use of computer-based information systems. To better visualize actual information system development activities, it was necessary to determine the general impact of these systems, their development in different functional areas and their major applications.

Churchill, Kempster and Uretsky in Computer-Based Information Systems for Management: A Survey, published findings regarding these factors. The study examined applications in operations, marketing, product and process

⁸"Litton's Electronic Information Machine," Business Week, MMCXVII (March 28, 1970), 158.

development, and general administration. The following material was drawn from the study.⁹

Major impact of information systems on firms included in the research was the automation of most clerical operations and some attempt toward integration of individual systems. Low level decision-making was being automated to a slight degree but automation of the elements of strategic planning or high level decision-making had not been accomplished. There was increasing formalization of the process associated with definition of information requirements, data inputs, users and timeliness of information.

Also, interdependence between quantitative models and information systems was increasing. Pressure for improved decision-making required consideration of possible tools that could aid in the process. Quantitative models were often useful in analysis and information systems were often required to provide data for use in the models.

Churchill, Kempster and Uretsky discussed applications in functional areas and described them as being extensive. These were:

operations: production planning, reporting and control; inventory control; process control.

⁹Neil C. Churchill, John H. Kempster and Myron Uretsky, Computer-Based Information Systems for Management: A Survey (New York: National Association of Accountants, NAA Research Study, 1968).

marketing: order processing; shipping; market analysis programs; order entry.

product and process development: a partner in achievement of research and engineering tasks; project control and data collection.

general administration:

accounting: collection and managerial analysis of data.

financial: cash management information; development of capital budgeting models.

personnel and formal planning: personnel data base; budget functions.

The authors concluded that the computer was now a significant part of the firms studied. It had moved beyond the clerical stage. Applications were now being undertaken in the managerial area which were broader in scope and concerned with improved decision-making.

Taylor and Dean have also completed research of computer applications by functional area in thirty-three highly successful manufacturing companies.¹⁰ Applications were similar to those discussed above and their findings of

¹⁰James W. Taylor and Neal J. Dean, "How to Manage the Computer," Harvard Business Review, XLIV (September-October, 1966), 98-110.

percentages of computer and systems effort directed toward different functional areas were interesting. Finance and accounting accounted for 47 per cent of the total effort; production for 16 per cent; marketing for 12 per cent; distribution for 11 per cent; research and development/engineering for 8 per cent; and planning and control for 6 per cent.

General interpretation of these findings is that accounting and financial functions were the first and easiest to automate because of high clerical operating content and an identifiable return in administrative savings. Since this area is now highly automated in many firms, additional effort can be directed toward development of other areas critical to successful operations. More systems with managerial versus clerical orientation will probably appear.

An allocation of future systems efforts by those same firms tended to substantiate this idea. For example, in the future finance and accounting efforts were expected to comprise 31 per cent of the total instead of the current 47 per cent. All other functional application efforts were to increase by at least 25 per cent except in the area of top management decision-making where an increase from the current 6 per cent to 7 per cent of total effort was

predicted. A similar study done later by Dean generally supported the earlier findings.¹¹

These findings also support the need for a study related to advanced information systems for purchasing. Purchasing was not included as an area for current or future development. Results of this study would add to the information base necessary for information system development in purchasing.

As applications of computer-based information systems have grown and are being utilized for more than clerical operations, so have the capabilities of these systems developed. Lipperman has outlined the following available computer-based information system capabilities:¹²

1. Ability to rapidly specify and organize large data files.
2. Provision of generalized file maintenance programs which allow users to easily maintain files previously specified.
3. Provision of "query language" capabilities which allow users to interrogate files, using very simple command statements.

¹¹Neal J. Dean, "The Computer Comes of Age," Harvard Business Review, XLVI (January-February, 1968), 83-91.

¹²Lawrence L. Lipperman, Advanced Business Systems (New York: American Management Association, AMA Research Study 86, 1968), p. 61.

4. Ability to easily specify complex reports within the "query language" request for information.
5. Some systems have been designed so that users can make inquiry to the system from remote terminal locations.
6. Some systems have been designed so that the inquiries come into the system as punched cards and are read into the computer from a card-reader located in the computation center.
7. Some systems have been designed so that the programmed application will guide the user through a procedure whereby the user will request unique data from the files; specify standard calculations that are to be made upon these data, or perhaps specify how the file should be changed; and finally, specify the type of report which would best serve his current purposes.

Factors Relating to Successful
and Unsuccessful Information
Systems

Information systems are becoming more sophisticated and consume large amounts of company resources in development and implementation. Are there factors which can influence whether a firm's efforts will be successful or unsuccessful.

Churchill, Kempster and Uretsky believe they have isolated three requirements for successful operation of advanced information systems:

A good information system or information base upon which to build--a data base.

A system staff which understands the management aspects of the problems being studied and an involved management which understands something of the computer and the systems approach--a management base.

Sufficient highly placed executive support to help cross organizational boundaries, to restructure activities where needed, and to overcome natural resistance to change--top level management support.¹³

McKinsey and Company research findings also showed differences between firms experiencing successful versus unsuccessful implementation and operation of computer-based information systems. Research results were that successful firms spent more money on their computer systems; executive responsibility for computer information systems was one level below the president; top management played an important role in the development of the systems; and computer applications of successful firms covered a broader area and were more selective. Applications were developed where the greatest overall benefit was thought to be obtainable.¹⁴

A number of other authors also supported the general theme of the above studies.¹⁵ Resources must be

¹³ Churchill, Computer-Based Information Systems, p. 141.

¹⁴ M. Valliant Higginson, Managing With EDP: A Look at the State of the Art (New York: American Management Association, AMA Research Study 71, 1965), p. 42.

¹⁵ See, Harold M. Sollenberger, Major Changes Caused by the Implementation of a Management Information System

available for use; top management must support the system; operating and systems personnel must cooperate in development of the systems; and analysis of potential information system applications is necessary prior to system design and implementation for best results.

Information Systems for Planning and Control

Examination of computer-based information systems within the planning and control framework will be useful to expand the theoretical background regarding analysis of system uses and potential.

According to John Dearden, computer-based information systems would have their most significant effect on operational control. The computer is best suited to process data with the following characteristics: a number of interacting variables; ability to obtain reasonably accurate values for these variables in a problem solving situation; necessity for speed; repetitive type of operation; and need for accuracy and large amounts of information.

He stated that the types of information required for operational control had these characteristics to a greater degree than information used for strategic planning and management control. Management control and strategic planning do not become significantly more effective due to

(New York: National Association of Accountants, 1968), pp. 49-69; Donald F. Cox and Robert E. Good, "How to Build a Marketing Information System," Harvard Business Review, XLV (May-June, 1967), 145-154.

computer-based information systems even though data handling costs may be reduced.¹⁶

Dearden has further written in discussing real-time systems:

Since strategic planning largely involves predicting the long-run future, I fail to see how a real-time management information system will be of appreciable use here. It is true that past data are required to forecast future events, but these need hardly be continuously updated and immediately available. Furthermore, much of the preparation of detailed strategic plans is done by staff groups. While these groups may on occasion work with computer models, the models would certainly be stored away, not maintained on-line between uses.¹⁷

Contradictions existed in the literature regarding Dearden's views but the trend seemed to indicate that the use of computer-based systems to assist and support strategic planning and management control was increasing. Churchill, Kempster and Uretsky reported that, "Not surprisingly, the use of computers in the top management activity of unstructured (or strategic) planning was quite limited since this is the area most difficult to deal with analytically."¹⁸ However, efforts were being made to

¹⁶John Dearden, "Can Management Information be Automated?", Harvard Business Review, XLII (March-April, 1964), 128-135; "Myth of Real-Time Management Information," Harvard Business Review, XLIV (May-June, 1966), 123-132.

¹⁷Dearden, "Myth of Real-Time Management Information," 127.

¹⁸Churchill, Computer-Based Information Systems, p. 13.

develop computer assistance in this area through simulations or analytical models which could provide approximate answers to questions. Information systems were also being developed with ready access which can provide information to previously unspecified management questions in any form desired.

Furthermore, the firms studied were using computer-based information systems to assist management to more effectively control and coordinate activities for which he had responsibility, mainly through providing by-product information from data bases established for operational control purposes.¹⁹

Brady stated that the computer has had little impact on overall top management decision-making. But, based on his research, computer-based information systems will have at least substantial impact in the future on the kinds of information received, volume of information received, accuracy of information received, timing of information received, kinds of decisions to be made, the decision process and top management organization.

For example, information received will be altered.

. . . The impact on the format of information reaching top management will be substantial. Many top management reports will be generated directly by the computer.

¹⁹Ibid., p. 12.

In some cases, information will be received by top managers on video display devices.²⁰

The literature reflected some uncertainty regarding the effectiveness of computer-based information systems for managerial control and strategic planning purposes. The available research indicated, though, that additional computer systems were being developed to assist in strategic planning, management and operational control. Therefore, opportunities exist for the design and implementation of systems which can utilize the full capabilities of the computer. Time-sharing is a capability which has potential for use in information system applications.

Time-Shared Systems

A review of literature was undertaken for purposes of obtaining additional knowledge about time-shared systems. Specific objectives were to determine:

1. Characteristics and classifications of time-shared systems.
2. Basic configuration and operations of time-shared systems.
3. On-line, real-time implications of time-shared systems.
4. Factors related to use of time-shared systems.

²⁰Rodney H. Brady, "Computers in Top-Level Decision Making," Harvard Business Review, XLV (July-August, 1967), 75.

5. Considerations related to use of commercial time-shared systems.

Characteristics and Classifications

A time-shared system was earlier defined as:

. . . a communications-oriented method of using computers. It is a technique that permits concurrent utilization of the same installation by two or more persons working at remote devices capable of direct, on-line access to the data processing equipment. Each of the users of a time-sharing system must have the ability to inquire into and add to or alter information in files accessible to the data processing installation in random access fashion, on demand.²¹

Various authors have established characteristics or features which further specify time-shared systems. For example, Shays presented four characteristics of time-sharing systems:

. . . (1) simultaneous to the degree that a number of people are using the computer at the same time, (2) instantaneous to the degree that all users receive responses to their interrogations within seconds--in some cases almost immediately, (3) independent to the degree that different services, programs or devices can be in use separately or in combination during any given period of time, and (4) general purpose to the degree that no restriction is placed on the kind of program or application involved.²²

Schwab added that a time-sharing system is a system shared by a number of users who have remote consoles

²¹James R. Ziegler, Time-Sharing Data Processing Systems (Englewood Cliffs, N. J.: Prentice Hall, Inc., 1967), p. 10.

²²Michael E. Shays, "The Feasibility of Real Time Data Processing," Management Services, II (July-August, 1965), 21.

directly connected to the system over communication lines. The system provides short response time to inquiries with short execution times by being able to commutate its facilities rapidly among users through program interrupt and by using appropriate scheduling rules utilizing time slicing.

Program interrupt allows a program that is being processed to be interrupted or halted, for example, upon receipt of new input data. Time slicing allows a problem to be serviced consecutively in a limited time period. Termination of a time slice requires the problem to be placed at the end of the problem queue if a round-robin scheduling approach is used. Execution of another problem then begins while the first problem awaits processing.²³

Ziegler listed five characteristics of a time-sharing system. These were:

1. On-Line.
2. Real-Time. The computer must be capable of serving all users on a real-time basis. Real-time defined as being within the time requirements established for individual applications processed.
3. Concurrent Access. Two or more users must be able to have concurrent remote access to the computer.

²³Bernhard Schwab, "The Economics of Sharing Computers," Harvard Business Review, XLVI (September-October, 1968), 66.

4. Integrity. The computer system must have the capability to provide complete security and privacy for all data and information stored and processed.
5. Functional Latitude. Characteristic subject to greatest variation. Systems may range from those dedicated to a single application for a particular user organization up to broad gauge installations serving diverse functions.²⁴

This section of the review improved understanding of concepts directly associated with time-shared systems. In addition, categories of time-shared systems have been developed and are useful for analysis.

Ziegler outlined a set of alternatives which can be used to describe the functional range of time-sharing classifications.²⁵

1. Systems with a single, fixed application program.
2. Systems with multiple application programs, each rigidly delineated.
3. General purpose systems providing programming language options and remote program writing and entry capability.

²⁴ Ziegler, Time-Sharing Data Processing Systems, p. 16.

²⁵ Ibid., pp. 17-18.

Another classification also separated time-sharing systems into three categories.²⁶

1. Unrestricted general purpose.
2. Restricted general purpose.
3. Dedicated system.

The unrestricted general purpose system allows use of various programming languages and varying applications. Restricted general purpose systems only have one programming language capability and varying applications. A dedicated system is a specialized system dealing with a specific problem or application.

The above classification systems can be used to describe different variations of time-shared systems for business applications. A common base of understanding has also been developed for the description of various systems in Chapter III.

Basic Configuration and Operations

Different time-shared system hardware configurations were discussed in the literature. The following hardware configuration and operations configuration were typical.

Figure 2 enables visualization of the elements of a typical time-shared system. Random access files allowing rapid, nonsequential data retrieval by the central processing unit and other peripheral hardware and controllers are

²⁶E. R. Cattaneo, "Time-Sharing Seminar in Print," Data Processing Magazine, VII (September, 1965), 18-23.

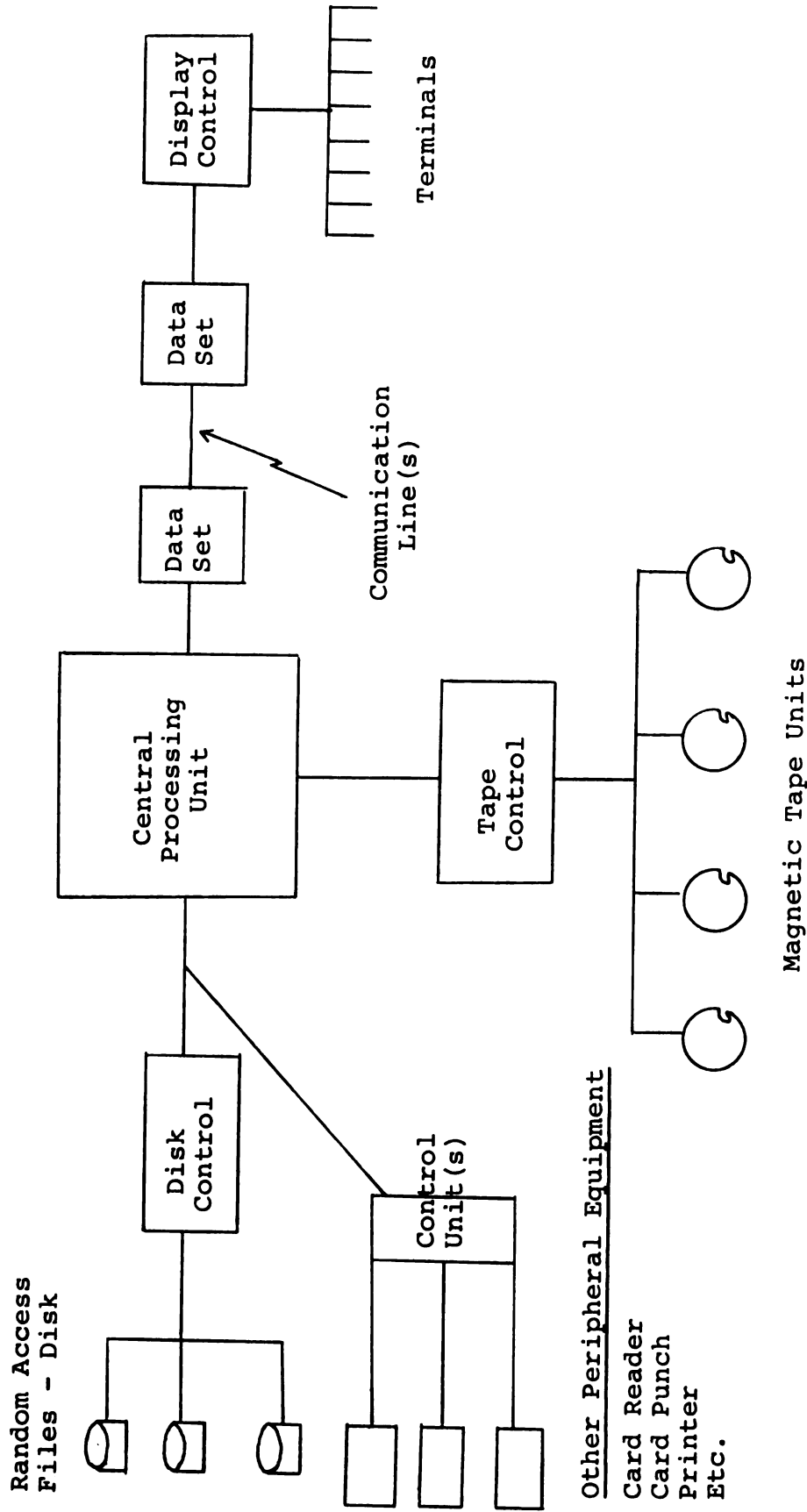


FIGURE 2

Schematic Diagram of a Typical Time-Shared System with Remote Terminals

depicted. Data communication requirements are also evident. There must be a means to convert business machine electrical signals into tones for transmission over communication facilities and for these tones to be reconverted into electrical signals recognizable by the receiving business machine. A data set accomplishes this conversion process.

Figure 3 outlines basic operations of a time-shared system. The executive program which resides in high speed core memory supervises operation of the total system.

Executive software responsibilities can be classified as:²⁷

1. Control of input/output from remote terminal.
2. Scheduling of computing time to tasks at hand.
3. Allocation of memory and storage.
4. Input/output control for using program.
5. Control over service operations.

Usually, application programs reside in bulk storage (disk files) when not in use but are retrieved and placed in swapping store (drum) when requested prior to transfer to working store and vice versa. It is necessary to have a swapping store as all active programs generally cannot be economically stored in high speed working memory. Scheduling routines of the executive determine when transfer occurs between the various sections. Interrupt and time-slicing concepts were utilized in the process as earlier outlined.

²⁷Ziegler, Time-Sharing Data Processing Systems, pp. 38-40.

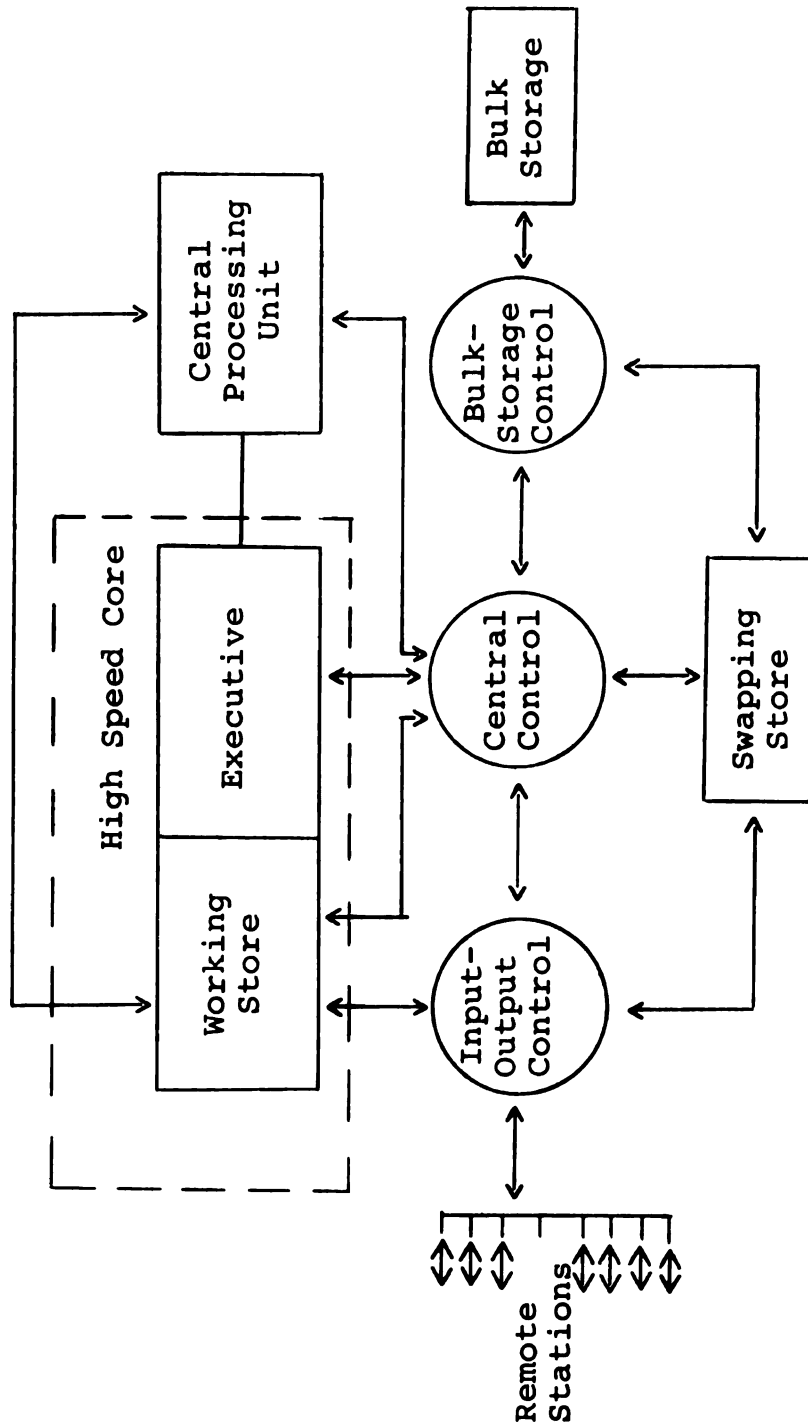


FIGURE 3

Schematic Diagram of Basic
Time-Shared System Operations²⁸

²⁸Douglas F. Parkhill, The Challenge of the Computer Utility (Reading, Mass.: Addison-Wesley Publishing Company, 1966), p. 97.

On-Line Real-Time Implications

Time-sharing systems have increased developmental capabilities of on-line, real-time and real-time oriented systems for business and other applications. Interest is increasing in the use and potential application of time-shared systems due to their operating capabilities.

Sprague in an early publication in the field wrote that due to fundamental economic and total-system pressures, a set of requirements are developed, which in conjunction with technical capabilities, lead to development of on-line real-time systems.²⁹

It was Sprague's contention that most business applications would be on-line real-time in the early 1970's. However, development is progressing at a slower rate and many believe that not all applications require on-line real-time processing.

Prince, for example, indicated that there were many situations where a real-time system is not a goal, and would be an inappropriate system for the organization.³⁰

Also:

The primary factor in the on-line or real-time system, of course, is the matter of time. How much benefit can be gained from reducing the response time? What new

²⁹Richard E. Sprague, Electronic Business Systems (New York: The Ronald Press Company, 1962), pp. 1-51.

³⁰Thomas R. Prince, Information Systems for Management Planning and Control (Homewood, Ill.: Richard D. Irwin, Inc., 1966), p. 285.

types of decisions can be made under a "no time delay" system? What are the estimated returns from these new types of decisions?³¹

The development of time-shared systems with easily obtainable on-line real-time capability has placed greater importance on examination of the time factor. Significance of the time element concerning information systems and their relationship to decision-making can be seen in Figure 4.³²

The time interval between the last actual measurement of the system and a specific decision-making point can

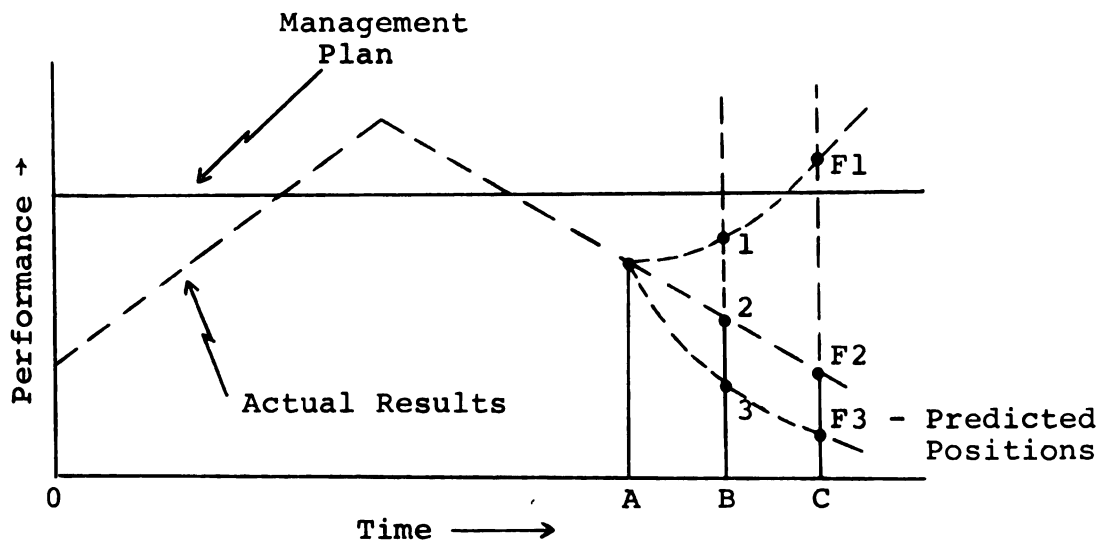


FIGURE 4

Effect of Performance and Measuring Time

³¹Ibid., p. 289.

³²Adopted from, Bartow Hodge and Robert N. Hodgson, Management and the Computer in Information and Control Systems (New York: McGraw-Hill Book Company, 1969), p. 147.

be very significant when controlling efforts to achieve the management plan.

For example, point B is both the current time and the point in time when a decision must be made. Point A represents the last measured position of the system and the distance between A and B can be considered a time lag or the difference between a situation existing and information reflecting this situation being used in decision-making. Hence, a problem could arise due to the time lag if the position of the system changed significantly.

If the system had moved toward point 1, an over-reaction in the decision could occur while if the system moved toward point 3, corrective action could have been too weak. Only if the system moved toward point 2 would the decision have been satisfactory.

Furthermore, according to Ziegler:

Time-sharing concepts have impacted management in two important ways:

1. Since the basic data processing activities of a business are handled on a more current basis, the information delivered to management is more timely.
2. With most of the critical information about a business accumulated currently in the files of a time-sharing system, the potential is opened for the preparation of data manipulation programs which have the effect of putting management on top of an organization's entire operating picture.³³

³³Ziegler, Time-Sharing Data Processing Systems, p. 88.

If one examined the problem of appropriate time lag related to information availability for a specific firm or system application in economic terms, three general variables would require consideration. These variables are time lag, value of knowing current position and cost of acquiring current position information.

Figure 5 illustrates the type of economic analysis that should be considered in the development of on-line real-time systems. The cost and value curves could be in different positions and shaped differently but are useful for the discussion as drawn. Information showing the current position of the system has both a cost and value to

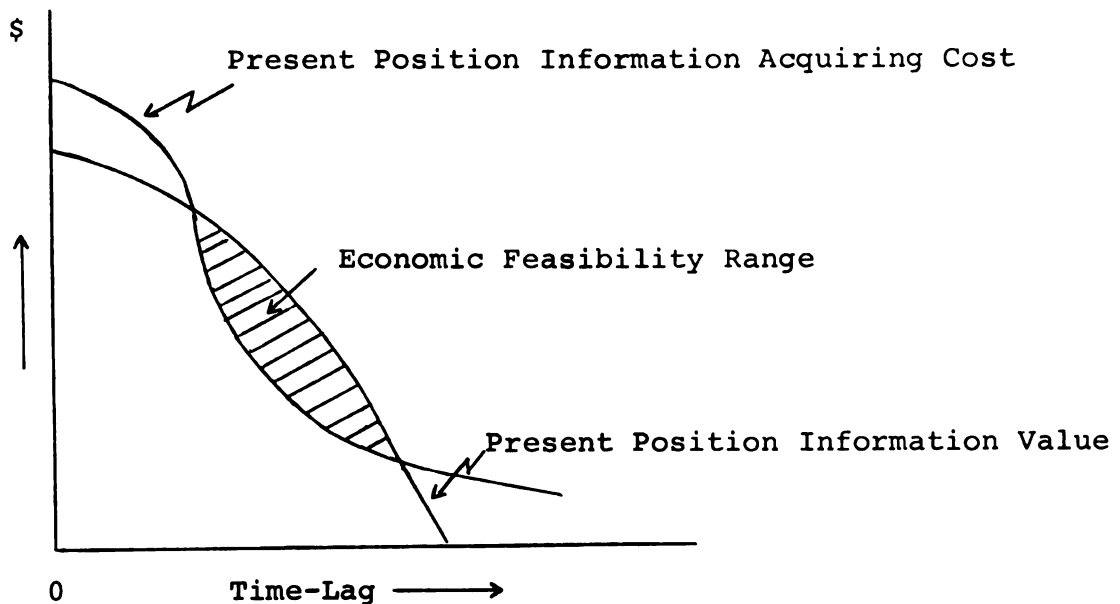


FIGURE 5

Information Cost-Value

the user. Each user must determine his region of economic feasibility and design his systems accordingly.³⁴

Questions concerning time lags and costs and benefits require consideration in the specific environmental context of proposed on-line real-time systems. Martin also implied the desirability of examining possible specific benefits of particular on-line real-time systems when he stated:

The delays involved in batch processing are often natural delays and little advantage can be gained by reducing them. But elimination of the necessity for such delays opens new and relatively unexplored possibilities for changing the entire nature of the data processing system--from a passive recorder of history (which of course is valuable for many decisions) to an active participant in the minute-to-minute operations of the organization.³⁵

A recent study by Zani further illustrated the need for thorough analysis in designing a real-time system to achieve improved performance results. Zani tested the generally accepted concepts of on-line real-time information systems by comparing six matched firms, three using batch processing systems and three real-time systems. Tested were the generally held views that real-time systems are more expensive than batch systems and performance should be better in those firms using real-time systems. Measurement criteria were established which included system costs,

³⁴Ibid., pp. 148-149.

³⁵Wainright E. Martin, Jr., Electronic Data Processing (Homewood, Ill.: Richard D. Irwin, Inc., 1965), p. 381.

operations effects and competitive effects. Performance was then measured.

The results of the study were that the real-time processing system cost less and better performance was not evident in firms using real-time systems.

Implications of the study were:

The findings of this study do not by any means disprove the generally accepted suppositions concerning real-time system benefits. The findings, however, strongly suggest two important factors. First, real-time computer systems do not automatically generate savings for a company; quicker information flow in and of itself has no value. Real-time systems yield benefits only if they are meaningfully integrated into a management process. Secondly, real-time systems do not necessarily provide a significant competitive advantage in every industry. The nature of the industry, competition and business may not provide an opportunity for the real-time user to gain a competitive advantage. Depending on the nature of the environment, a company using traditional data processing equipment can satisfactorily compete with a company using real-time systems.³⁶

Finally, a listing suggesting situations where on-line real-time systems may be considered was drawn from an issue of the EDP Analyzer by Bluementhal.³⁷

1. Customer order-entry systems where product is perishable . . . or where competition is forcing faster customer service or better inventory control.

³⁶William M. Zani, "Real-Time Information Systems: A Comparative Economic Analysis," Management Science, XVI (February, 1970), B-355.

³⁷Sherman C. Bluementhal, Management Information Systems: A Framework for Planning and Development (Englewood Cliffs, N. J.: Prentice-Hall, Inc., 1969), p. 169.

2. . . . to support irreversible transactions, where decisions involve complex analyses--granting of loans, credit sales and such.
3. Controlling highly interrelated operations, where if one operation falls behind schedule, many others are affected; an example is production control in the aerospace industry.
4. Collection of input data where a high likelihood of error in human operations exists.
5. Providing fast response from data files . . . , e.g., military command and control, stock exchange price quotations, police file of stolen cars, etc.
6. Where service to a customer can be complex and must be performed in a short period, e.g., real-time savings banking.
7. As an aid to operating people performing their tasks on a demand basis, e.g., file searching, etc.

Factors Related to Use of Time-Shared Systems

Economic and Situational.--The literature included additional references to economic considerations of time-shared information systems which were both system and user oriented. Bauer illustrated factors favoring both time-shared systems and batch systems. Arguments for on-line

systems were user efficiency, large-computer efficiency, application flexibility and physical factors such as accessibility and nearness. Pro-batch arguments were directed toward computer, software, terminal and data communication costs associated with time-shared systems.³⁸ He further indicated some of the reasons for the higher costs of time-shared systems. These were:

1. Additional working storage features.
2. Multi-access to and independent operation of working storage.
3. Large internal high speed memory.
4. Increased storage capacity of auxiliary memories.
5. Hardware speed degradation.³⁹

Teager stated that among the advantages which have or could be given for time-shared, multiple-access systems, the following should be considered:⁴⁰

1. Computing capacity becomes less expensive and more efficient as speed, memory size, peripheral make-up, and therefore the cost of a system is increased.
2. The only feasible method of turnaround time reduction is utilization of multiple-access and time-sharing.

³⁸Walter F. Bauer, "The Economics of On-Line Systems," in On-Line Computing, ed. by Walter J. Karplus (New York: McGraw-Hill Book Company, 1967), p. 79.

³⁹Ibid., pp. 96-97.

⁴⁰Herbert M. Teager, in An Analysis of Time-Shared Computer Systems, by Alan Lee Scherr (Cambridge, Mass.: The M.I.T. Press, 1967), pp. 19-25.

3. Users find that multiple-access greatly affects their effectiveness.
4. Existence of a large centralized store of programs and data is essential to the user.
5. Centralized, multiple-access systems are more versatile, reliable, and flexible than single-user or batch modes.

It was further noted that these statements were only true in a highly qualified sense. At best, they could be restated as trade-off possibilities.

The trade-off concept is of importance in establishing time-shared system applications within a firm due to economic constraints. The system should be worth its cost at least in belief if not in actual fact. This was aptly stated by Fagan, "When these costs (of a time-shared system) to the user are totaled, the sum must be in balance with the economic utility of the service provided the user and must be competitive with alternative ways of doing the same job."⁴¹

One author presented four questions which, if adequately answered, would justify or not justify the use of a time-shared system. These questions were:

⁴¹Robert E. Fagan, "Systems Analysis and Design," in On-Line Computing, ed. by Walter J. Karplus (New York: McGraw-Hill Book Company, 1967), pp. 52-53.

1. What can you accomplish with time-sharing?
2. What value do you place on these accomplishments?
3. What will time-sharing cost?
4. Is it worth it?⁴²

These were very basic considerations but their analysis would probably lead or point to a specific direction regarding a decision.

Ziegler summarized the above when he further stated that the criteria for economic evaluation of time-sharing computers were basically the same as for any other data processing system: advantages must be weighed against costs, with the decision riding in the balance. In economically evaluating time-sharing systems, there were special advantages and disadvantages. Advantages included better CPU utilization, lower individual job costs, faster availability of results, better programming and debugging capability, improved throughput and productivity for analytical calculations, potential use by small businesses subscribing to utility services and direct use of computer file data in management information systems. Disadvantages included higher equipment costs, new terminal and line cost expenses, costs of reprogramming, possible use of terminals as toys or status symbols and the repercussions

⁴² Ziegler, Time-Sharing Data Processing Systems,
p. 35.

of upset empires within a user organization as a result of changes brought about by time-sharing concepts.⁴³

The generalizations regarding advantages and disadvantages of time-sharing must be examined closely in each situational context to accurately determine their validity. This is especially so when dealing with state-of-the-art advancements. Need for situational analysis was supported by Hodge and Hodgson when they wrote, "Much has been said about real-time computer operations and on-line computer systems. Yet, comparatively little has been done to integrate the system into instrumentation and people loops."⁴⁴

Commercial Time-Sharing.--A firm contemplating time-shared system development has the possible alternatives of developing an internal facility or using a commercial time-sharing service bureau. Decision criteria related to obtaining internal computer systems were not examined as this decision is primarily a capital budgeting problem. The literature included a number of publications concerned with factors to be considered in deciding whether to use a commercial time-sharing firm and these will be discussed.

⁴³Ibid., pp. 35-36.

⁴⁴Hodge and Hodgson, Management and the Computer, pp. 2-3.

An example of cost effectiveness arguments that illustrated positive and negative factors of commercial time-sharing utilization were:⁴⁵

<u>Positive Factors</u>	<u>Negative Factors</u>
1. Fast response.	1. Cost of communication facilities.
2. Reduced user capital investment.	2. Executive control requirements.
3. Improved utilization of computer power.	3. Reliability and maintenance problems.
4. Improved balance between user needs and user costs.	4. System saturation problems.
5. Greater computer power for use.	5. Lost time due to "swapping."
6. Convenient access to broader data and procedure base.	
7. Flexible system augmentation and modernization.	
8. Reduced user maintenance and operating costs.	

⁴⁵Parkhill, The Challenge of the Computer Utility, p. 139.

It became evident that an organization must consider its own needs to determine if a factor is, in fact, a positive factor supporting use of a commercial time-shared system.

Dorn wrote that:

The first questions that a prospective user of a time-sharing system should ask are directed toward himself, not to the vendor. The user must ask:

1. Do I really need time-sharing services or do I need remote batch processing or do I need a small stand alone computer?
2. If I need time-sharing, what is the fundamental thrust among our users? Are they of the scientific, engineering, compile and go to class, or do they want to debug parts of larger problems, or are they commercially oriented and looking for a data base or transaction system?
3. What is the prospective use after the initial, attractive newness has worn off?
4. What, considering the needs of the users, is the value of being able to transfer the work load to a competitive system?

These questions and there are others, suggest that the first thing a user must evaluate is himself.⁴⁶

Rullo developed a set of tests or points which could be examined by each potential user with respect to his needs prior to utilization of a commercial time-sharing facility. These tests were:

1. System availability--is the time-shared system available at the time and day which you require it?

⁴⁶Philip H. Dorn, "How to Evaluate a Time-Sharing Service," Datamation, XV (November, 1969), 221.

2. Operational suitability
 - a. Language--is the language availability suitable to your needs and can it be learned easily on a conversational basis?
 - b. Application programs--what type of application programs are required for your operation and are they provided by the commercial time-sharing firm?
 - c. User assistance--exactly what type of assistance do you need and is it provided?
 - d. Special hardware--determine the type of terminal most suited to your needs and eliminate those systems which cannot support the terminal.
3. Contractual suitability--is it possible to enter into an agreement that suits your needs? For example, a short-term agreement if you are just gaining knowledge as to the advisability of full utilization of time-shared systems.
4. Benchmark tests--will the system support your type of operations in test runs.
5. System load--is the system capable of adjusting to an increased work load or will performance suffer?
6. Pricing structure.⁴⁷

⁴⁷Thomas Rullo, "Selecting a Time Sharing Service," Data Processing Magazine, XII (March, 1970), 42-47.

These were a number of vital questions which should be of importance to time-shared system users and especially to those considering use of a commercial time-sharing facility versus an in-house batch processing or time-shared system.

Analysis of time-shared systems and how a firm accesses the system is becoming more important to many organizations. A recent study found that of 497 firms who were current users of commercial time-sharing services, 170 intended to establish in-house systems by 1975 and 142 of the 170 would have installations by 1971.⁴⁸

In addition, more use is being made of time-shared systems for business oriented applications.⁴⁹ This was supported by Ziegler:

During the early phases of the development of time-sharing concepts, these (scientific) applications tended to steal the scene. . . . In the long run, however, the bulk of time-sharing usage will, necessarily, lie in the bread-and-butter, volume jobs of business and industry.⁵⁰

The growth in business time-sharing applications will probably increase. An important part of this study is

⁴⁸Bohdan O. Szuprowicz, "The Time-Sharing Users: Who Are They?," Datamation, XV (August, 1969), 57.

⁴⁹Richard T. Bueschel, "Timesharing Today," Data Processing Magazine, X (December, 1968), 18-21.

⁵⁰Ziegler, Time-Sharing Data Processing Systems, p. 50.

to identify purchasing applications that are suited for time-shared system development.

Interactive Nature of Time-Shared Information Systems

The use of time-shared information systems includes a man-machine interface through use of terminals. The literature included discussion of the general significance of this on-line interaction.

Rationale describing the need for man-machine interaction in a conversational mode was discussed by Emery.

The great advantage of a man-machine partnership is that it permits the allocation of problem-solving tasks according to the comparative advantage enjoyed by each partner. The capabilities of the two are quite complementary; hence the combination of man and computer represents a distinctly more powerful system than one constrained to employ only a single component.

Man's superiority lies primarily in his ability to recognize subtle patterns, to recall relevant information through association, to learn, to exercise intelligence and originality, and to draw inductive inferences. Even in cases in which the computer technically could be endowed with similar capabilities, it is often uneconomical to do so. Therefore, man-machine systems will draw heavily on these comparative advantages of man.

The computers superiority over man is well known to the point of triteness. All of its advantages rest on its ability to handle massive quantities of data with great speed, reliability and accuracy. But these characteristics, when coupled with the flexibility and logical capabilities, inherent in the stored program computer, provide an extremely powerful supplement to man's problem solving abilities. . . .

Man-machine systems will usually require computer time-sharing. The man must be provided a quick response from the computer if an especially close rapport between the two is required. This means that the man must be on-line to the computer.⁵¹

⁵¹James C. Emery, Organizational Planning and Control Systems (New York: The Macmillan Company, 1969), pp. 517-518.

Further, McDonough and Garrett stated:

By knowing what levels of detail are available, the manager can find his place relative to his responsibility at a given organization level. He can then decide on whether he can work with summarized data or must get into the details. In a situation where an information display console is available, the manager can work with gross information but call for lower and more detailed information, on occasion, to double-check his reasoning.⁵²

It was also found:

. . . that a large extension of ability to calculate and analyze is available through the use of a terminal connected to a large computer. Generally, the justification lies in time saved. It may be customer's time that is saved, but the basic situation is similar. Time required in correcting errors and waiting for reports to be produced with corrected data is also being saved by computer-controlled terminal displays which guide people in preparing input. This is reflected quite readily in the time-sharing systems available commercially.

Information retrieval is an important application for new equipment. Systems have been designed to permit an approach almost like browsing. Without knowing the name or number of a product, customer, or specially trained employee, one might enter a file and pick his way through successively more detailed displays until he learns the specific identify of what he is seeking. . . . The justification for these systems is time-saving as opposed to the emphasis on expected clerical reductions that justified acquisition of many first- and second-generation computers.⁵³

Richard G. Canning provided additional comments on the use of information systems utilizing terminal capabilities when he stated that these types of fast response

⁵²Adrian M. McDonough and Leonard J. Garrett, Management Systems (Homewood, Ill.: Richard D. Irwin, Inc., 1965), p. 177.

⁵³Joseph F. Moynihan, "Applications of New Input and Output Equipment," in Information Processing for Management (Elmhurst, Ill.: The Business Press, 1969), p. 164.

systems had advantages over batch systems with turnaround time requirements. These advantages were reduced human waiting time and reduced idle time of things. For example, the level of inventory can be reduced with faster order processing or reduced procurement lead times. Other advantages were the ability of users to handle more complex tasks based on inquiry capability to a broad data base thereby allowing an individual to become more of a generalist through direct man-machine interface. Finally, the ability to keep in step with external events such as the constant changes which can occur in a manufacturing environment.⁵⁴

The use of on-line terminals in either a real-time or real-time oriented mode achieves a direct man-machine interface with certain advantages. However, as with all changes in information systems design and structure, a different set of problems or considerations can arise.

Canning outlined some of the problems associated with fast response (or time-shared) information systems. First was the problem of complexity and size. As the computer-based systems grow larger, complex problems develop such as inter-arrival times of requests becoming less than the service time causing possible system failure.

⁵⁴Richard G. Canning, "Progress in Fast Response Systems," Journal of Systems Management, XVIII (July-August, 1967), 21-22.

A second problem was the greater importance placed on internal memory. Many batch systems run with 16,000 core memory, but time-shared systems generally require greater internal memory due to larger programs and queues of transactions. If the queues become longer more access to mass storage is required which again takes more time. Therefore, larger queues and increased performance pressure on the system will develop, possibly leading to some type of failure if the system does not have enough capacity to meet unforeseen situations.

A third area for consideration was whether the available generalized software programs for terminal control would be able to handle systems of varying complexity or would specialized software have to be developed by individual users. Two additional considerations were reliability and security or privacy. Batch systems could go down without serious consequence and most people would not know about it. However, with an on-line system many people will know and confidence in the system may be diminished. Also, now that many people have potential access to information, security systems and the establishment of privacy must be thoroughly considered.⁵⁵

Direct man-machine interface through terminal utilization with a time-shared system may not be required

⁵⁵Ibid., pp. 23-24.

or advantageous for all applications. However, the advantages of this type of system are important enough to justify close examination of the different applications to determine where the system could be used. According to Bluementhal:

. . . It is probable that terminals can be applied more readily in the routine administrative and operational areas, since the need and benefits may be more easily established in advance. Justification of terminals for management control tends to be more speculative. Managers may require less rapid response but higher-quality information display than the administrative and operational activities, whose requirements seem to be more predictable and more "real-time."⁵⁶

Purchasing Information Systems

This phase of the literature review examined published material related to purchasing information systems. The objective was to determine available information primarily oriented to time-shared information systems for purchasing.

A review of purchasing and materials management text books showed that they generally included a short section on electronic data processing presenting advantages and problems. A passing reference or usually no comment was made regarding time-shared information systems and their capabilities.⁵⁷ Other books such as those by Bluementhal

⁵⁶Bluementhal, Management Information Systems, p. 171.

⁵⁷For example, Wilbur B. England, Procurement; Principles and Cases (Homewood, Ill.: Richard D. Irwin,

and Dearden and McFarland discussed information system development as related to logistics.⁵⁸

Blumenthal discussed in detail a logistic information system of a hypothetical industrial corporation which was called LOCIS for Logistics Operations Control Information System. LOCIS had three subsystems: RMOCIS--Raw Materials Operational Control Information Subsystem, PROCIS--Production Operational Control Information Subsystem and SPOCIS--Salable Product Operational Control Information Subsystem. RMOCIS consisted of the materials scheduling, purchasing, receiving-inspection-storing, inventory control and distribution control functions. Analysis of these systems was useful in segmenting and classifying a user's needs as defined by the comprehensive taxonomy. Considerations related to time-shared information systems were not examined.⁵⁹

A review of periodicals such as Purchasing, Purchasing Week, Journal of Purchasing and computer oriented publications did not lead to any published material which

Inc., 1962); Dean S. Ammer, Materials Management (Homewood, Ill.: Richard D. Irwin, Inc., 1968); J. H. Westing, I. V. Fine and Gary Joseph Zenz, Purchasing Management: Materials in Motion (New York: John Wiley and Sons, Inc., 1969).

⁵⁸Blumenthal, Management Information Systems, pp. 39-84; John Dearden and F. Warren McFarland, Management Information Systems (Homewood, Ill.: Richard D. Irwin, Inc., 1966).

⁵⁹Ibid., pp. 61-84.

was directly concerned with the objectives of this study. Most articles were concerned with batch processing, nonman-machine interface environments.⁶⁰

A few articles were available which described some aspect of the purchasing system which consisted of applications in an on-line real-time mode. The March 21, 1968 issue of Purchasing included an article, "Real-Time Computer Keeps Materials Moving," which described a system where data could be input and information was immediately available through use of an on-line terminal. Open purchase order status information was available on a terminal inquiry basis and included part number, vendor name, quantity ordered, quantity received and quantity rejected.

Receiving also had terminal access to the file and compared actual receipts on arrival to specified requirements, noting critical items where so indicated by a code. Furthermore, receiving reports were prepared immediately on the printer terminal to correspond to actual receipts.

Some advantages of this system over a batch processing system were noted such as time savings, reduced paperwork and better control over critical items.⁶¹

⁶⁰For example, see, "How IDP Speeds Purchasing," Purchasing LIII (August 27, 1962), 60-64; Herbert E. McLean, "Biggest Buying Job in the World," Purchasing, LIX (July 15, 1965), 89-94.

⁶¹"Real-Time Computer Keeps Materials Moving," Purchasing, LXIV (March 21, 1968), 53-55.

"Next in Automated Procurement: Visual Data Processing" described the possible use of a cathode-ray tube (CRT) terminal in purchasing. Foreseen was an automatic buying process for low value items, instant information availability to buyers for high value and critical purchases with capability to press certain keys on the CRT and have a purchase order automatically prepared.

Also described was a soon-to-be implemented information system which would include: direct entry by a clerk of purchase order data, change orders and quotations to a CRT; hard copy preparation of purchase orders from this data; instant access by purchasing personnel through a CRT to purchase order status, buy history and random type information.⁶²

The October 14, 1968 issue of Purchasing Week included an article describing design and implementation of the real-time system discussed above which utilized a cathode-ray tube terminal for input and inquiry purposes.

The system was further described as being activated when an order was placed by a buyer and a clerk input all associated data by using a keyboard on the CRT. Thereafter, part data was stored on random access disk until the part was no longer active. Purchase orders were also

⁶²Herbert E. McLean, "Next Step in Automated Procurement: Visual Data Processing," Purchasing, LXI (September 22, 1966), 63-65.

automatically printed. Furthermore, when material was received, the receiving clerk typed in packing slip data to the computer memory via a terminal in his area and a receiving report was automatically printed by an on-line printer in the receiving area. All specified information was stored in computer memory available for immediate information retrieval when the need arose. Weekly and monthly reports were also printed.

Some of the benefits gained from the system compared to the prior manual system were faster information retrieval, increased ability to handle larger work loads without increasing personnel and automatic preparation of purchasing documents.⁶³

The information content of this article was more comprehensive than any of the other publications. It provided a concise case study of a particular system.

However, it should be noted that none of the above publications attempted to examine time-shared information systems for purchasing purposes in other than a particular situation. Also, no significant mention was made regarding costs, major problems or change factors or major developmental considerations which were associated with time-shared systems.

⁶³ John C. Kromrey, "How Control Data's Buyers Use EDP," Purchasing Week, XI (October 14, 1968), 24-25.

Donald A. Lindgren in The Use of Electronic Data Processing in Industrial Purchasing Departments of Large United States Corporations completed a study describing EDP usage by purchasing departments, factors related to this usage and directions of EDP development. This study provided useful insight into EDP usage in purchasing. For example, the purchasing functions most frequently automated were defined. On the basis of a mail survey, these functions were: (a) scheduling orders and deliveries, (b) follow-up of delivery promises, (c) determining economic order quantities, and (d) inventory control.⁶⁴ In this instance, the focus of the study was not on time-shared information systems for purchasing. This was also the case in other published material reviewed but not discussed in this study.⁶⁵

The fact that very little was found in the literature concerned with time-shared information systems for purchasing can be explained by the recent development of

⁶⁴Donald A. Lindgren, "The Use of Electronic Data Processing in Industrial Purchasing Departments of Large United States Corporations (Ph.D. dissertation, University of Wisconsin, 1968).

⁶⁵See, for example, Jeremiah Cantor and Frank Loda, Mechanized Purchasing Systems (New York: American Management Association, AMA Management Bulletin 104, 1967); J. William Widing, Jr. and C. Gerald Diamond, "Buy by Computer," Harvard Business Review, XLII (March-April, 1964), 109-120; A. E. Kollios and Joseph Stempel, Purchasing and EDP (New York: American Management Association, 1966).

the field which began in the mid-1960's. Walter Bauer discussing on-line systems said that:

. . . The newness of the field probably is the best explanation of this dearth of literature and analysis. Those sufficiently knowledgeable about on-line systems to make such contributions are deeply engaged in analyzing and designing, where the attention is turned to the technical factors only and the economic implications are given less emphasis.⁶⁶

Therefore, the recent development of time-shared systems in general and the lead time necessary for development of these systems, explains in some part, the lack of supportable generalizations or studies regarding time-shared information systems for purchasing.

Chapter Summary

As a background for this study of time-shared information systems for purchasing, a review was made of available literature on computer-based information systems, time-shared information systems and purchasing and materials management information systems. The review included many topics but the reported results were limited to those most directly related to the study.

Examination of the literature related to general computer-based information systems provided documentation in several areas. A framework of planning and control using the Anthony definitions of strategic planning, management

⁶⁶Bauer, "The Economics of On-Line Systems," p. 96.

and operational control was established. The need for computer-based information systems was primarily based on increasing business complexity and rapidly changing environment.

Applications in various functional areas such as operations, marketing, product and process development and general administration were examined, as was the growing sophistication of applications and system capabilities. Time-sharing was then mentioned as a significant advancement which could be utilized in information systems.

It was noted that within the planning and control framework, different types of information were required and therefore different application capabilities should be provided by the system to satisfy these needs. Furthermore, future computer-based information systems will provide greater assistance in the management control and strategic planning areas than they do now.

Also, factors associated with successful information systems were identified in the research. Success associated factors were a sufficient data base, management and technical knowledge and top management support.

The concepts discussed were all directly pertinent to the successful design and implementation of time-shared information systems for purchasing purposes. Knowledge and experience gained from earlier systems development and operation provides applicable insight necessary for

development of information systems with on-line real-time capabilities for planning and control purposes.

Further examination of the literature was completed to determine information available on time-shared information systems and their use for purchasing and materials management.

A basic time-shared configuration and operational characteristics were presented. On-line real-time implications were examined. A general finding was that potential time-shared applications required detailed analysis to determine the payoff for individual situations. Factors favorable and unfavorable to time-sharing system implementation were discussed. Considerations related to use of a commercial time-sharing facility were examined.

The review related to the interactive nature of time-shared systems discussed the natural comparative advantages of man and machine and their ability to complement each other. Additional discussion centered on the ability of the man-machine team to quickly answer questions from a data base in the required detail.

Finally, purchasing literature was examined to determine content related to time-shared information systems used for purchasing. The literature included very little information on time-shared systems. A few articles discussed specific cases of on-line real-time systems but no

comprehensive studies were found. A number of publications and studies considered major applications of batch information systems in purchasing and these were discussed or were cited.

CHAPTER III

FIELD STUDY OF TIME-SHARED PURCHASING-MATERIALS MANAGEMENT INFORMATION SYSTEMS

Introduction

This chapter examines the current use of time-shared information systems for purchasing-materials management as ascertained through field research.

Eight different firms were visited. Eleven separate purchasing-materials management organizations were studied because the field research included four separate divisions of one firm. These firms were large multiproduct, multi-supplier firms. All, except one, were included in The Fortune Directory of the 500 Largest United States Industrial Corporations or The 50 Largest Utilities.¹ The one exception was an academic institution, the University of Illinois, which was included in the research sample because it appeared to be a leader in administrative and purchasing information systems development.

¹"The Fortune Directory: 500 Largest United States Industrial Corporations," Fortune, LXXXI (May 1970), 184-200; "The Fortune Directory: 50 Largest Utilities," Fortune, LXXXI (May, 1970), 212.

The time-shared purchasing-materials management information systems in these firms were the basis for the eight systems described. In addition, three organizations which did not currently have operational time-shared systems for purchasing were included because they were developing such systems. Developmental information obtained from these firms is included in this chapter.

Following the field research, an analysis of the time-shared systems which were examined led to the development of an information system classification model. This model is presented as a part of this chapter so that a firm can locate its purchasing-materials management information system relative to the classification categories, visualize other system capabilities and possibly better determine if its current system is most appropriate for its needs.

This classification model will be presented prior to explaining the various systems studied so that the model can be used to help explain other research findings. The discussion outline to be followed in this chapter is:

1. Classification model.
2. Time-shared systems primarily used for planning and control.
3. Analytical applications of time-shared systems.
4. Synopsis of major data and information input/output classifications.

Topics two and three were separated so as to differentiate between time-shared system applications that relate directly to the planning and control of material and parts flow and those applications indirectly related to this flow but which can improve purchasing performance by the application of analytical techniques.

Classification Model

Development of the following classification model was based on information obtained from the literature review and from the analyses of the systems observed in the field research.

Time-shared information systems can be generally identified by three basic variables:

1. Time.
2. Input-processing.
3. Output.

The primary time variable is time lag. This includes: (1) the time lag between the occurrence of an event and data input to a system reflecting this occurrence; (2) the processing time lag or how much time is required computationally; and (3) the time lag between when computations are completed and the information is available to users. The sum of these time lags is the time difference between an event actually occurring in the environment and the availability of this information for planning and control purposes.

Input-processing can be described as either batch or real-time. Batch processing indicates that data is collected and processed once per given time period. This processing usually is in a sequential manner.

Real-time input-processing indicates that task performance data are input to the information system upon occurrence of the task and processed. Thus, real-time processing requires on-line terminal use while batch processing may or may not utilize direct access terminal capability.

The third basic model variable, output, is described by batch and real-time characteristics as follows:

1. Batch output--paper or hard copy reports generally available only after sequential processing which causes distinct information availability time lags.
2. Real-time--information retrieval is on-line with fast direct access through terminals to the central processing unit. Variations of real-time output are:
 - a. Real-time: restricted output formats--information can only be obtained from this direct access system by means of separate programmed reports. The number of report formats available in a system can vary considerably as can the number of information elements presented on each available output format.

- b. Real-time browsing--a direct access system which enables a user to identify several key variables which can be combined for report purposes. For example, a buyer may require information on all purchase orders and dollar value of parts placed with a certain supplier in the last six months. Instructional statements can be input to the terminal specifying these three variables and the computation to be performed by the computer. Specified output information will then be presented via the terminal.
- c. Real-time combination--this system has the capability for browsing and includes a number of available reports for which software is developed.

Both cathode-ray tube (CRT) and typewriter/printer are used with real-time output systems. The CRT terminals also often have printing capability for use when required. Furthermore, the output system may include batched hard copy reports in addition to the real-time output. Most real-time output systems do utilize batch output for certain applications.

The input-processing and output variables are used to categorize time-shared purchasing-materials management information systems as shown in Figure 6.

Input-Processing \ Output	Batch	Real-Time: Real-Time: Alternatives
	Batch	Real-Time: Real-Time: Alternatives
Batch	A	B
Real-Time	C	D

FIGURE 6

Purchasing-Materials Management Information System Classifications

In summary, based on variables discussed, the basic configurations of purchasing-materials management information systems are:

<u>Input-Processing Variable</u>	<u>Output Variable</u>
1. Batch	Batch
2. Batch	Real-Time: with Alternatives
3. Real-Time	Real-Time: with Alternatives
4. Real-Time	Batch

The time variable perceived by purchasing-materials management and resource availability are the primary determinants of the basic system configuration established in accordance with the classification system in Figure 6. Technological capability is available for firms to establish

these types of information systems on an internal basis or utilize a commercial service bureau. The third generation of computers with time-shared system capability facilitates the development of real-time applications.

Time-Shared System Configurations and Applications

Various time-shared system configurations and applications were being used for purchase material and part flow planning and control purposes in the firms visited. Each time-shared system will be described using the following characteristics related to the hardware system and to the purchasing or materials management system.

Purchasing-Materials Management System

1. Activities organizationally defined within the purchasing-materials management function.
2. Purchasing-materials management activities included in the time-shared information system application.
3. Data files, input responsibility and input-processing time lag.
4. Purchasing-materials management uses of the system.
5. Terminal locations and rationale.
6. Average response time of the system to user requests.

7. Classification of the system and whether internal or external to the using organization.
8. Organizational control of system.

Hardware System Configuration

1. Central processing unit.
2. Storage means.
3. Terminal types.
4. Data communications.

No reference is made to specific brand names of hardware because this dissertation makes no attempt to evaluate the merits of competing computer equipment.

System 1--Aerospace Vehicle Manufacturer

Responsibilities formally delegated to the procurement department of this organization included buying, receiving, receiving inspection, and functional administration of the purchasing system. Additional responsibilities related to the materials management information systems under study were production and inventory control.

This information system used two basic files, procurement and inventory management. The inventory management file utilized inputs from procurement reflecting buying and material flow activities. Two large scale third generation computer systems were used to operate the total system which is depicted in Figure 7.

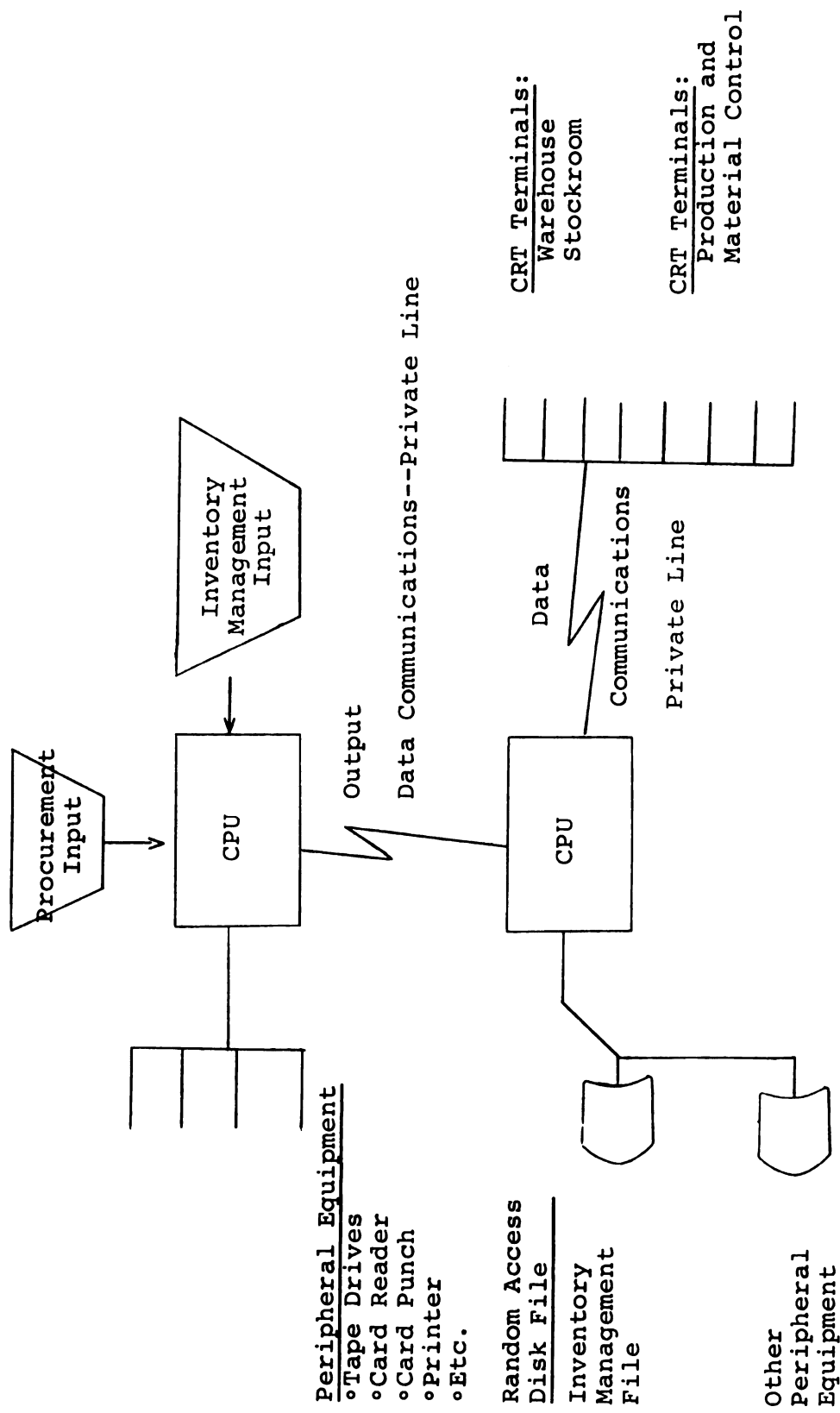


FIGURE 7

System 1--Aerospace Vehicle Manufacturer

Data input reflecting purchasing activities was prepared on paper tape simultaneously with the typing of purchase orders. The paper tape was then converted to magnetic tape and processed on the main central processing unit. Inventory management file update was on a punched card to magnetic tape basis for processing. Both the inventory management and procurement files were updated on a batch basis.

Procurement information was only available on a batch output basis. The processed data from the inventory management file which reflected procurement and inventory activities was then transmitted over commercial communication lines to a time-shared system from which users can have direct access to the inventory management file. Output terminals in use were cathode-ray tubes and were connected to the computer via private lines.

Input to the inventory management file was updated daily by the inventory control group and three times per week by the procurement group, which meant that some of the procurement data could be two days old. Information retrieval was real-time with one CRT format available.

Examples of information which was obtainable on-line from the inventory management file by part number according to a master account or project number are:

1. Requirements or usage--quantity of parts or materials required for a project or job.

2. On request--purchase requisitions written for parts or materials for which no purchase order has been completed.
3. On order--purchase orders written for parts or materials to meet requirements.
4. Inventory inspection--indicates parts or materials received which are in quality control.
5. Charge direct inspection--indicates quantity of parts or materials which are to go directly from quality control to the user.
6. Repair balance--number of parts out of the company facilities for repair which will be available for later use.
7. Stock balances of parts or materials by storage location.

Data update responsibility was assigned to a centralized administrative group in both procurement and inventory control to gain task specialization advantages.

Users of the on-line system were primarily operational personnel in production and material control and inventory stores. The output information was used for improved planning and control associated with specific projects and general material flow. For example, a production planner by requesting and receiving an almost instantaneous display of information regarding the quantity of a certain part in stock, on order, or on quote could

quickly and accurately adjust a production schedule to meet the current situation. Information was also used to provide management with accurate responses to their questions, and location of parts in the firm can be quickly determined. Average response time of the system was two to three seconds.

Terminals were located in inventory storage areas on a one per area basis. One terminal per inventory storage area was sufficient for current business volumes and two to three operating personnel usually used the terminals. Production and material control attempted to have a terminal for every two to three planners. This allowed ease of use based on work load and prevented any significant congestion at terminals.

This was a type B system based on the classification model, or a batch input-processing, real-time information retrieval system with limited output format capability. Furthermore, the system was internal to the firm and utilized two unrestricted general purpose computers.

Organizational control and maintenance of the system was with a computer operations group in the administration department. The using departments such as inventory control and purchasing participated in design and development of the system and were also currently involved in the development of future plans.

System 2--Electrical Equipment
Manufacturer

Organizationally defined purchasing responsibilities of this firm included buying component parts, material, supplies, services, a subcontract function, and processing of interplant orders. Inbound and outbound transportation and material disposal activities were also included within the purchasing department.

Receiving, production control, and accounts payable were outside the purchasing department but related to the time-shared system.

Figure 8 represents the basic computer system configuration and data files available to users. The system consisted of two large scale third generation computers. One system acted as a back-up if the other went down. Also included in the system were disk files and tape drives, card readers, punches, and other peripheral equipment. Terminal equipment was of three types: cathode-ray tube, printer-typewriter and printer supporting the CRT's. Data communications were over private lines.

Data files on random access disk which were available to users were the master purchase order file, supplier master file, open requisitions file, production and inventory control file, and accounts payable file. These files were separate but various functional users had access to them, thereby integrating the information retrieval effort.

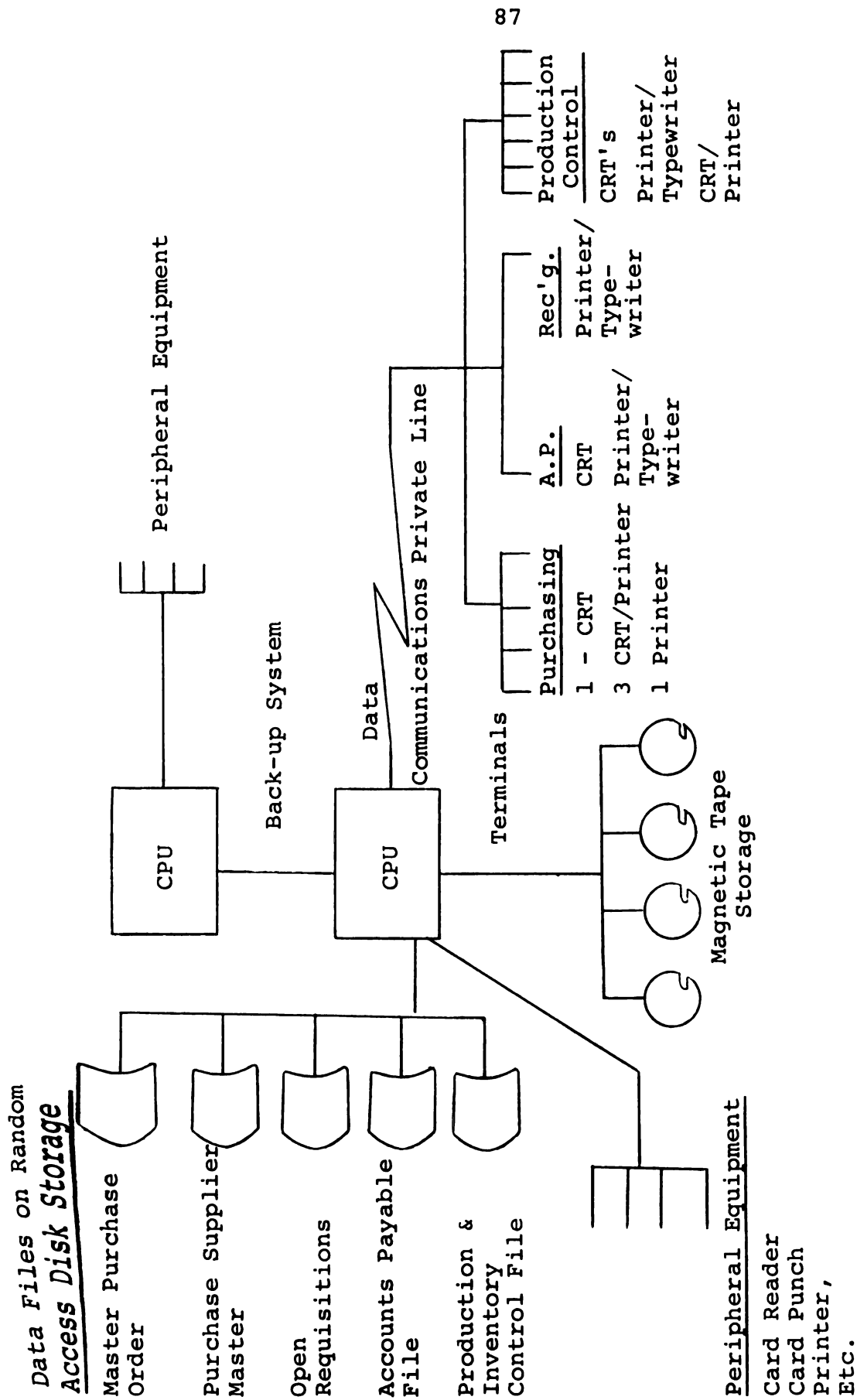


FIGURE 8

System 2--Electrical Equipment Manufacturer

Data update responsibility was centralized for the buying, production and inventory control, and accounts payable groups due to the benefits obtainable with specialization of labor by a data handling group. Operating documents were forwarded to a data collection and input section where activity data was converted to punched cards which were then transferred to tape and these to disk for on-line use.

Receiving transaction information by-passed the central data handling operation and was converted to punched cards in receiving after material was received. These cards were directly forwarded to the computing area for conversion to tape and then to disk files on a daily basis.

Data input to the disk files was updated daily indicating activities that occurred during the working day. These inputs were then available for real-time information retrieval with browsing capability. Information was at maximum one day old.

Time-shared system users such as management, buyers, expeditors, systems personnel, traffic, production and inventory control, and warehouse receiving and inspection personnel had access to data in the files on a job involvement basis. A security code identifying the user had to be input to the system when requesting information of any type.

Many bits of data were included in the time-shared system files and could be combined as required. For example, there were eighty-five different data inputs in the master purchase order file which related to all open purchase orders or those closed less than ninety days. The following examples give some indication of the content of this file.

Data Elements in Master Purchase Order File

Account Number	Part Number
Accounts Payable Closed Date	Price
Amount Invoiced	Product Code
Buyer Code	Promise Date
Commercial Availability	Promise Date Changes
Open Dollar Commitment	Purchase Order Number
Confirmation Date	Quantity Ordered
Last Invoice Date	Received to Date
Last Received Date	Price Variance Reason Code
Next Delivery Date	Receiving Area
Requisition Date	Number of Rejections
Days Between Deliveries	Set-up Charge
Engineering Change	Ship to Department
Expediting Request Code	Supplier Name
FOB Code	Supplier Number
Freight Allowed	Terms Code
Date of Last Invoice	Transportation Charge
Material Code	Unit of Quantity

Order by Department

Value Code

Part Name

Additional data were available in the other random access files in the system. For example, the production and inventory control file contained ninety-one data elements reflecting activities of material flow.

Operating personnel, such as buyers, were the primary users of the information system data base. Analysts in purchasing administration also used the data in analytical applications to be discussed later. Management utilized the terminal capability to a limited extent.

The major type of information required by buyers was related to supplier delivery information, i.e., what has been received. Additional information most often requested was related to historical activity information available on the master purchase order file. Various users also used the system to obtain open requisition and open order information for planning and control purposes.

Four terminals were available in the purchasing office and consisted of two CRT's, one printer supporting the CRT's and a typewriter/printer. Another CRT was located near the traffic office which was separated from buying personnel. A large number of CRT's, printers and printer/typewriters were available in the production and inventory control area. Warehouse receiving/inspection also had a typewriter/printer terminal and accounts payable a CRT and printer/typewriter.

The terminal equipment available to buying and administrative personnel appeared inadequate to service their needs. A study by purchasing administration indicated that five CRT's and three typewriter/printers were required in the buying area. This was a terminal to user ratio of one to seven or eight and is required to provide adequate service to purchasing personnel at current business volume. Additional terminals were to be obtained when funds become available.

Information was available to users via typewriter/printers, cathode-ray tubes, and printed copy of the information displayed on the CRT as required. The maximum response time of the time-shared system was approximately forty-five seconds for complex information requests. Most responses were within ten seconds.

This was a type B time-shared purchasing information system which was a batch input, real-time output system with browsing and terminal report printing capability. It was internal to the firm and was unrestricted general purpose.

Organizational control of the system was external to purchasing in the systems and data processing group. Purchasing personnel, though, were involved in design, implementation, and training related to the system.

System 3--Durable Consumer Products Manufacturer

Materials management responsibilities related to this firm's time-shared information system were concerned

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with supplier performance and planning and control related to incoming parts and materials shipments, receipts and usage. The system had direct interfaces with suppliers who in total provided 92 per cent of the volume of parts and materials to be used by the purchasing plants.

Figure 9 describes the general system configuration which incorporated a large scale third generation computer. A file which included parts released for production and shipment and suppliers was maintained. Terminals were typewriter/printers and were located internally and externally to the purchasing firm. Data communications were carried over commercial lines. Average response time of the system was generally less than five seconds.

Data update varied with the location doing the updating. For example, update or initial loading of the random access file by the production control group occurred upon release or change of parts requirements. This was done on a batch input basis, card to tape to disk. Suppliers updated the file directly through terminals based on their planned parts shipment activities. These suppliers input information regarding planned shipments as follows:

Ship Date	Gross Weight
Carrier	Part Number
Rail Car Number	Purchase Order Number
Bill of Lading	Receiving Plant Code
Type Container	Quantity Shipped
Number of Containers	Year-to-Date Quantity Shipped

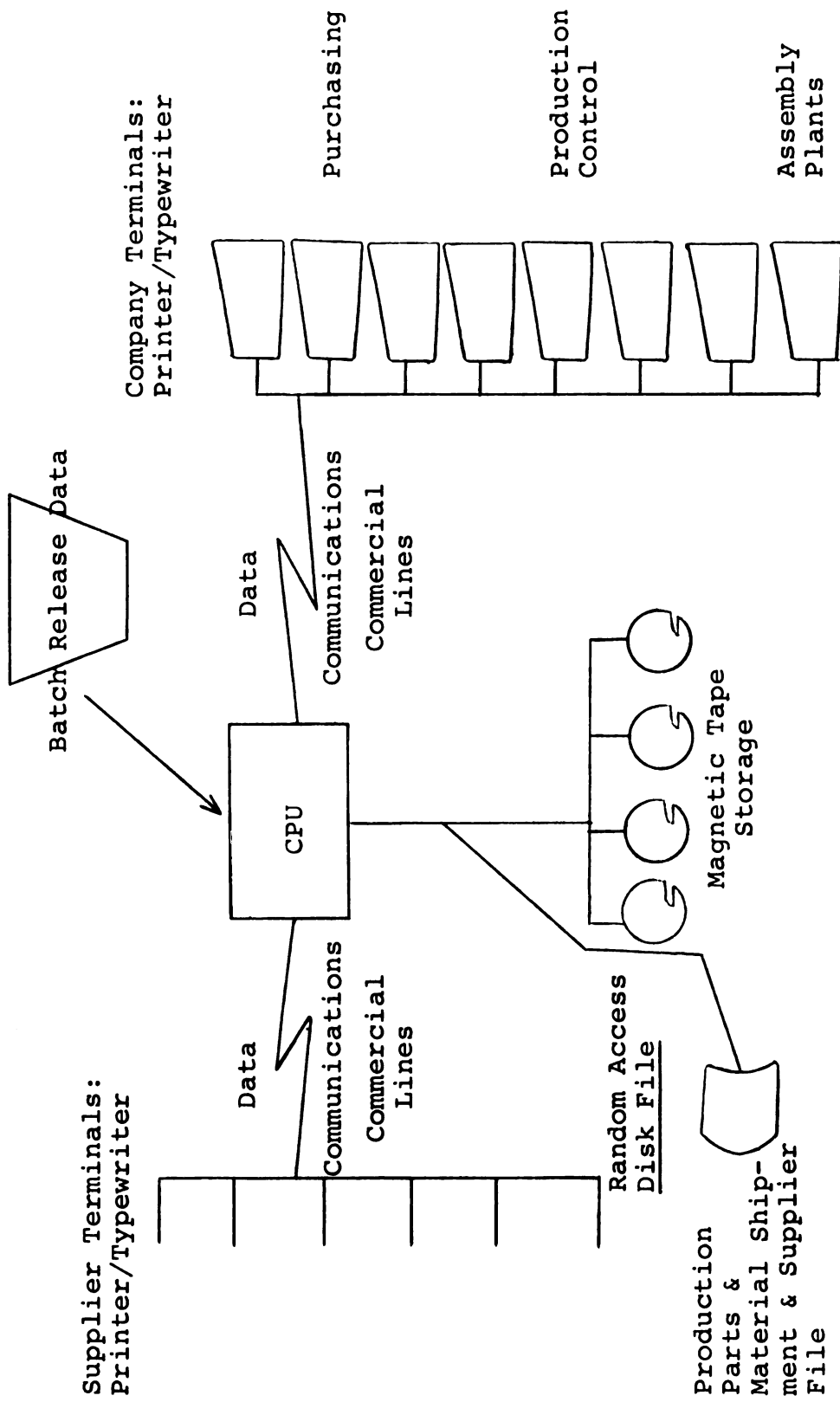


FIGURE 9

System 3--Durable Consumer Products Manufacturer

This information was then available on a direct access basis by staff and plant production control and purchasing personnel. The information was specifically used to determine possible parts and material flow and production interruptions that could occur because of late delivery or insufficient quantities being forwarded to the using plant. Production plants also inquired about the latest status of any parts which they believed to be in short supply. Production schedules were adjusted based on this information to avoid line or plant stoppages and corrective action was taken with suppliers by purchasing where necessary.

Primary users of the terminals were operating personnel. In addition, production control, purchasing and top level plant management often used the information obtained from the system to isolate critical problem areas so that corrective action could be taken.

Terminals were located in corporate and plant production control, purchasing and supplier locations. Each supplier required one terminal to provide advance shipment information to the system. Corporate production control had one terminal per product group and these were located to minimize walking distance for planners in the group or about a maximum walking distance of twenty feet. Assembly plants had terminals on the basis of one per plant for planning and control as did purchasing.

This was a combined type B and D system which had both batch and real-time input-processing and limited real-

time output capability. It was internal to the firm and was a dedicated system.

Organizational control over the system was with the operations data processing group but significant influence on system design and operation was exerted by the production control systems group.

System 4--Electrical Equipment Manufacturer

This materials management information system included buying, receiving, receiving inspection, production and inventory control, and accounting activities. The buying and receiving functions were formally included in a purchasing department. Receiving inspection, production and inventory control and accounting were outside the formal purchasing organization.

The configuration of the system is depicted in Figure 10 and consisted of a third generation computer with associated peripheral equipment including random access disk storage, magnetic tape, card reader and punch and line printer. Terminals were cathode-ray tubes with keyboard and printer. Data communications were by private lines.

The materials management time-shared information system included data for production parts. Information was available from a master part file, master vendor file, and master purchase order file.

Examples of data included in the master purchase order file are:

Random Access
Disk Files

Master Part
File

Master Vendor
File

Master Purchase
Order File

Other Peripheral
Equipment

Card Reader
Card Punch
Line Printer
Etc.

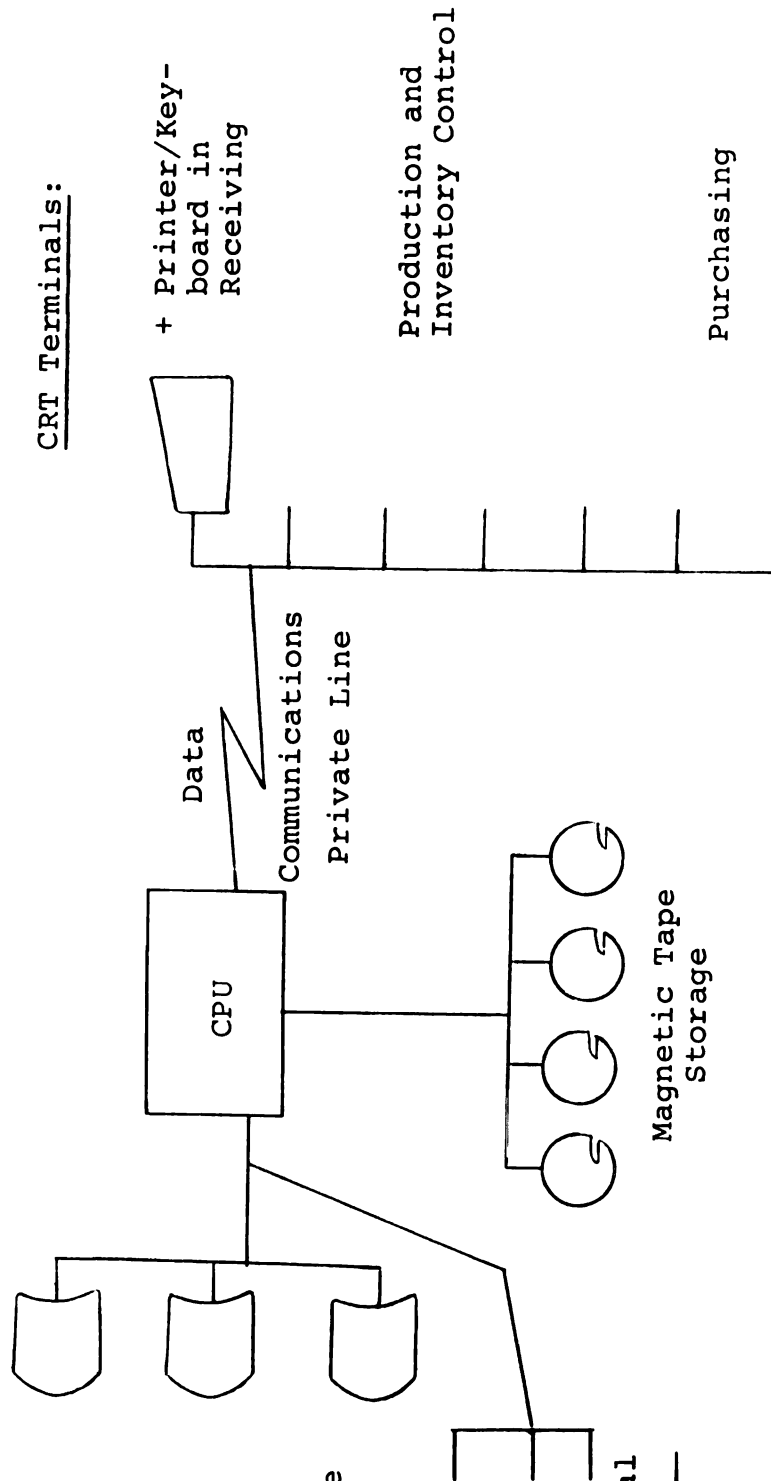


FIGURE 10
System 4--Electrical Equipment Manufacturer

Purchase Order Number	Acknowledgement
Change Order Number	Purchase Order Closed
Change Reason	Last Activity Date
Purchase Order Date	Interdivisional Account
Buyer Code	Standard Cost
Buyer Name	Part Number
Vendor Code	Part Revision
Vendor Name	Part Description
Ship Via	Unit of Measure
FOB	Specification Drawing
Terms	Unit Price
Business Type	Total Quantity Ordered
Account/Project	Total Quantity Received
Requisition Number	Total Quantity Returned
Requisitioner	Charge Items--one through three indicating charge code and amount
Extension Number	
Internal Routing	Delivery Data--one through twenty indicating quantity, required date, promise date
Reference	
Confirm Code	Transactions--one through twenty-two indicating type, quantity, date, reference, freight charge
Confirm Date	
Government Contract	
Government Priority	Inspection Codes
Tax Code	

The master purchase order file was updated and processed on a real-time basis. Input-processing for the master part file and master vendor file was done on-line via a CRT terminal once each day reflecting an accumulation of data.

Data update to these files was accomplished by a specialized group in the purchasing department, and by receiving personnel utilizing CRT terminals. Furthermore, specific terminals with both input/output capability were assigned to the data input personnel with responsibility for updating the files. The other terminals were restricted in input capability to help prevent incorrect data being input to the files.

Information was available from the system on a real-time and batch output basis. Batch output was generated by converting data on disk files to tape. Real-time output was in the form of receiving reports, vendor status, part status, and purchase order status.

Receiving reports were generated at the receiving dock in real-time upon receipt of material. Receiving personnel typed in receiving data on the CRT keyboard and the central processing unit immediately located required information which pertained to the particular purchase order for that shipment. The receiving report format was then displayed on the CTT with the required information. A print key was then pressed on the CRT which caused the data to be printed on receiving documents at the printer station. These documents were then used to move the material and provide records for purchasing and accounting.

The real-time vendor status report enabled users to quickly review a vendor's name and address, shipping method,

FOB terms, outstanding purchase orders and to ensure that the supplier was on the master vendor file. This information was available in one format on the CRT and was called by typing in a code referring to the file.

Part status information was also available in one format on the CRT and was retrieved by use of a code. The user could review revision stage, part number and description, unit of measure used, commodity classification, file code, procurement lead time, specification control drawing, standard cost, any outstanding purchase orders for the part and ensure that the part was on the master part file.

Purchase order status was also available in real-time and information from the file was available in two forms. One reflected purchase order record information and the other showed delivery schedules by part number and number of actual transactions.

Purchase order record information had three output formats available on the CRT. Output one indicated purchase order and any change order numbers, vendor, buyer, part number, account or project, requisition number, confirming reference, confirming method, confirming date, tax code, requisitioner, phone, internal routing, government contract, government priority, order acknowledged, order closed, last activity date, and change order reason-date. Output format two indicated purchase order and change number, vendor,

vendor name and address, ship via method, FOB point, payment terms, and business type. Output format three indicated purchase order and change order number, part number, part description, unit of measure, unit price, total quantity ordered, and various change requirements.

Delivery and transaction information was also available in three output formats. Format one showed purchase and change order number, part number, total quantity ordered, and delivery schedules. The delivery schedules indicated quantity, required date, promise date, and deliveries. Format two showed actual delivery transactions which have occurred on the specific purchase order by showing date, reference, quantity received, quantity returned, and freight charge. Output format three combined transactions totals and balance due of the purchase order. In addition to the information on output format two, format three showed number of transactions, totals of the categories, and balance due.

Additional documents and reports were prepared by the system in a batch mode. These included purchase orders, purchase change orders, activity reports for purchase and change orders, and receiving and shipping. Also prepared were open purchase order status reports, open purchase order delinquency reports, commitment reports, variance reports, price history reports and reports which showed purchase orders that have been removed from the active file.

The time-shared materials management information system was primarily used by operating personnel such as buyers in the performance of their job and in anticipation or reaction to management requests for information. Some examples of system uses were: obtain purchase order and vendor information, determine whether material has been received and establish expediting and inspection priority to be given to scheduled incoming shipments. In addition, an economic order quantity model built into the system enabled buyers to quickly input variable data and obtain information regarding preferred lot size purchases. Management was utilizing the report capabilities of the system but was not actively using the terminals.

Terminal locations were established where real-time information was believed to be needed by the firm. These areas were receiving, production/inventory control, and purchasing. Other functions would operate on a batch basis. For example, accounting utilized batch processed information in printed copy such as a commitment report, variance report, and price history report.

One terminal was necessary in the receiving area to handle the current volume per day of incoming parts and material. In production and inventory control and purchasing one terminal for every two to three personnel was believed necessary to provide information retrieval capability without waiting lines forming.

This was primarily a type D system which was a real-time input-processing, real-time information retrieval system with development of programmed output. It was a dedicated time-shared system and was internal to the firm. Average response time was less than five seconds.

The time-shared information system was organizationally controlled by the systems and data processing group. Significant time and effort was and is being put forth by the system users, especially the purchasing department, in the design and continued development of the system.

System 5--Space Propulsion Units and Parts Manufacturer

The time-shared materials management information system at this firm was part of what appeared to be a sophisticated information systems development program throughout the firm. The system included requirements inventory control, material and parts inventory control, and a purchase order module.

A purchasing department had responsibilities for purchase of raw material, hardware, labor, tooling, experimental and research products, support services, and for subcontracting. It also included the inventory management responsibility. A stores and distribution department, which was at the same level as purchasing, included facilities and supply, traffic and fleet operations, warehousing,

receiving, and surplus sales. Requirements control originated in engineering and manufacturing.

Basic configuration of the system is shown in Figure 11. Two large scale third generation computer systems were available with one primarily a back-up system. Storage was on both tape and random access disk. The disk files contained requirements inventory control, material and parts inventory control, and purchase order information. Three types of terminals were used and included a printer/typewriter, a specialized document preparation unit to prepare traveling documents for material and parts after they had been received, and a cathode-ray tube. Data communications were by private lines.

Data update occurred in both batch and real-time modes. Receiving data which reflected purchased part and material receipt were input immediately to the material and parts inventory control file through a typewriter/printer terminal. A daily batch update procedure was followed for the purchase order module and for some data in the material and parts inventory control file such as inspection results and inventory withdrawal.

The time-shared system also prepared inspection, travel order and stock withdrawal documents at the specialized terminal immediately after receiving data were input to the system. Parts or material were then moved from the receiving area to inspection to production operations or inventory stock.

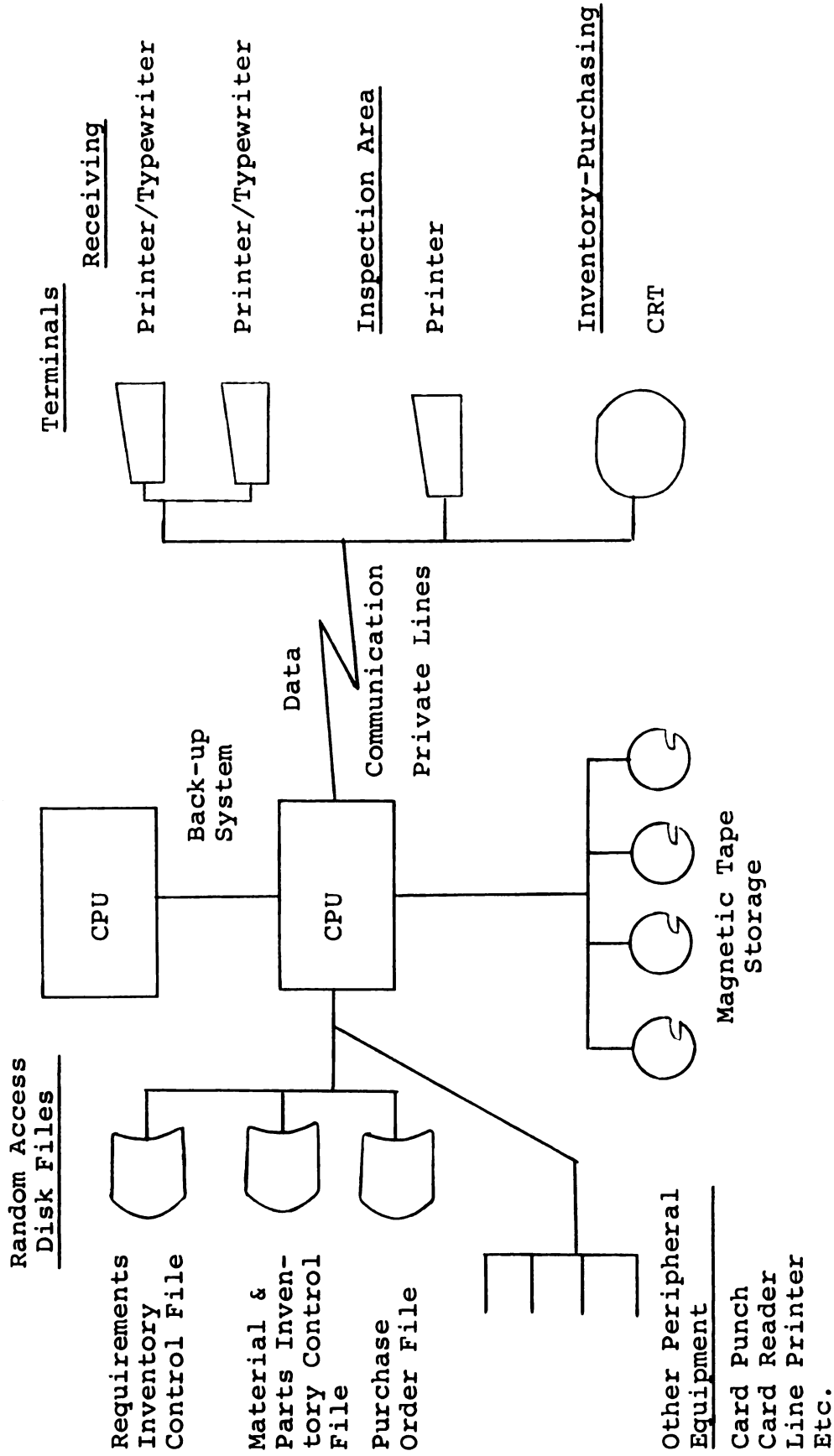


FIGURE 11

System 5--Space Propulsion Units and Parts Manufacturer

Data input responsibility was assigned to specialized groups. Designated receiving clerks updated receiving data while specialized administrative groups performed the input process in other areas. For example, a purchasing administration group utilized a flexowriter to prepare paper tapes from purchasing documents which were transferred to magnetic tape and processed daily. This specialization increased the validity of data input due to training and complete familiarity with the job.

Information retrieval and document preparation were limited to specific formats. Receiving could only input data or receive information regarding certain data and information elements. These were purchase order and item number, vendor, requisition number, quantity received, date received, catalog number if applicable, material part number, inventory account number, unit of measure, inventory quantity on hand, on-order quantity, quantity in receiving, quantity currently allocated to a specific job, required delivery quantity, and quantity short.

The CRT terminal in the parts and material inventory and purchasing area allowed information retrieval by part number or purchase order number for specific pieces of information useful to evaluate and/or expedite the material and parts flow. Furthermore, other printed reports were available from the system on a daily, weekly, monthly, and as requested basis. Users of the system were primarily operating personnel.

Terminals were located in the receiving department to be used as material arrived. Two terminals were required for the volume of business. The document preparation terminal was located near the inspection area which would be alerted by the automatically prepared documents that parts and material would be soon arriving for inspection and movement to production or inventory. A terminal was also located in the purchasing and inventory control office area which was used to obtain part and material status information. Average response times were about three to five seconds.

This was a combined type B and D system with batch and real-time input-processing and real-time output capability. The system was internal to the firm and was a general multipurpose system.

System development was primarily the responsibility of the computer and data processing group which worked with the various using groups.

System 6--Electrical Equipment Manufacturer

This firm formally defined purchasing responsibilities as buying, warehousing, and receiving. The time-shared purchasing information system was used to improve project planning and control related to price, quantity, quality, and total cost by recording and analyzing data related to these activities.

The system utilized a large scale third generation, unrestricted general purpose computer system. Figure 12 indicates the system configuration. Storage was on random access disk with a tape back-up. The terminal used was a printer/typewriter with input/output capabilities. Data communications were by private lines.

Data update procedure was in a real-time mode as soon as documents reflecting purchasing activities were received in a specialized data handling and input area. Information was obtained via terminal by a material analyst. Standardized output programs were stored in memory or information was obtained by preparing specialized programs.

Examples of input data are project designation, part number, part control code, change number, quantity used per project assembly, proposed total units to be produced, proposed unit price of purchased parts and material, actual units to be produced, actual price paid for parts and materials, any mortality allowance and purchase order number. Information was then available based on the type of analysis performed on the available data. An example was a comparison of current actual costs to proposed budget costs of a project.

Information retrieval was generally by the material analyst and response time was generally two to five seconds. Most of the information obtained from the system, though, was used by purchasing management in making decisions

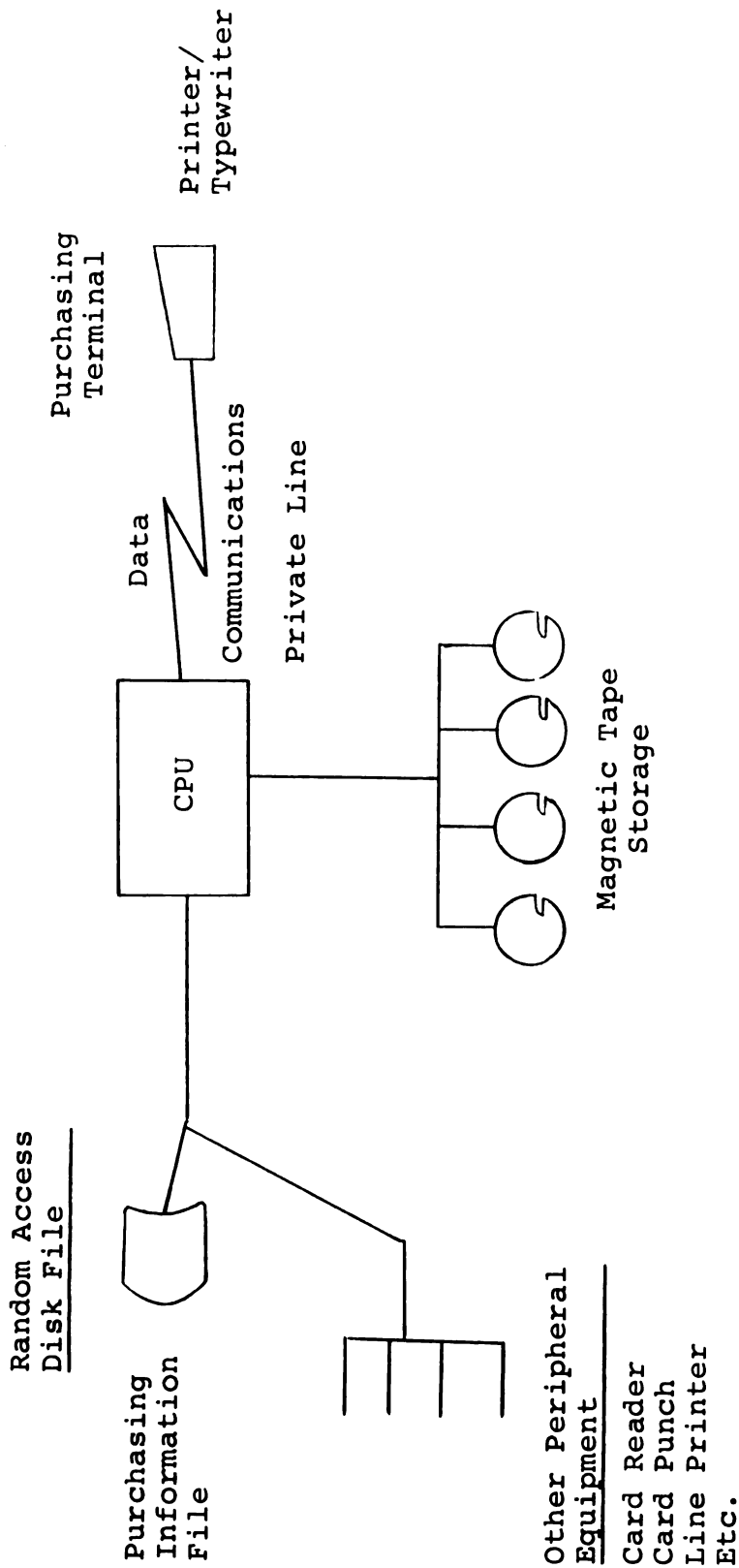


FIGURE 12

System 6--Electrical Equipment Manufacturer

related to part and material purchases for specific projects and the taking of corrective action where necessary. Also, information from the system was used by a contract and proposal group in estimating future project costs.

The system was a type D system with small storage files. It was a real-time input-processing and real-time output system with specified reports and additional specialized output capability. The system was unrestricted general purpose and internal to the using firm.

Organizational control over the system was with the computing and data processing group. Initial development of the system was by purchasing and an outside commercial time-sharing firm. As use increased and a time-shared computer system became available within the firm, the system was converted to the internal computer.

System 7--Space Propulsion Units and Parts Manufacturer

This time-shared materials management information system was being implemented in the firm visited. Other time-shared systems had been developed and were operational such as an engineering release system, a production parts location system, a work-in-process system and a management accountability system. Final implementation of the system studied will integrate the overall material flow cycle from incoming material through distribution. This firm seemed to be a leader in systems development and was moving toward complete systems integration.

The time-shared materials management information system integrated the requirements cycle or the estimation of needed parts and materials, inventory control, buying, receiving and issuing and certain financial transaction reporting information.

Figure 13 outlines the basic computer system configuration. It was a large scale third generation computer system. Storage was on random access disk with tape back-up. Terminals were cathode-ray tubes and typewriter/printers with data communication lines being private lines. Information was available from the requirements, purchase order, inventory, receiving and issuance, and financial files.

All original data update is to be on a real-time basis due to rapidly changing operating conditions. Responsibility for data input will be with specialized personnel in material requirements, purchasing, inventory control and warehousing groups because of task specialization benefits.

The primary purpose of the time-shared system will be to reduce the material or parts flow time into and through the firm to the customer. The system will also enable automatic preparation of buy requisitions, material inventory withdrawal documents, material analysis and management reports. Also available will be financial reporting, contract cost accounting, and customer billing information.

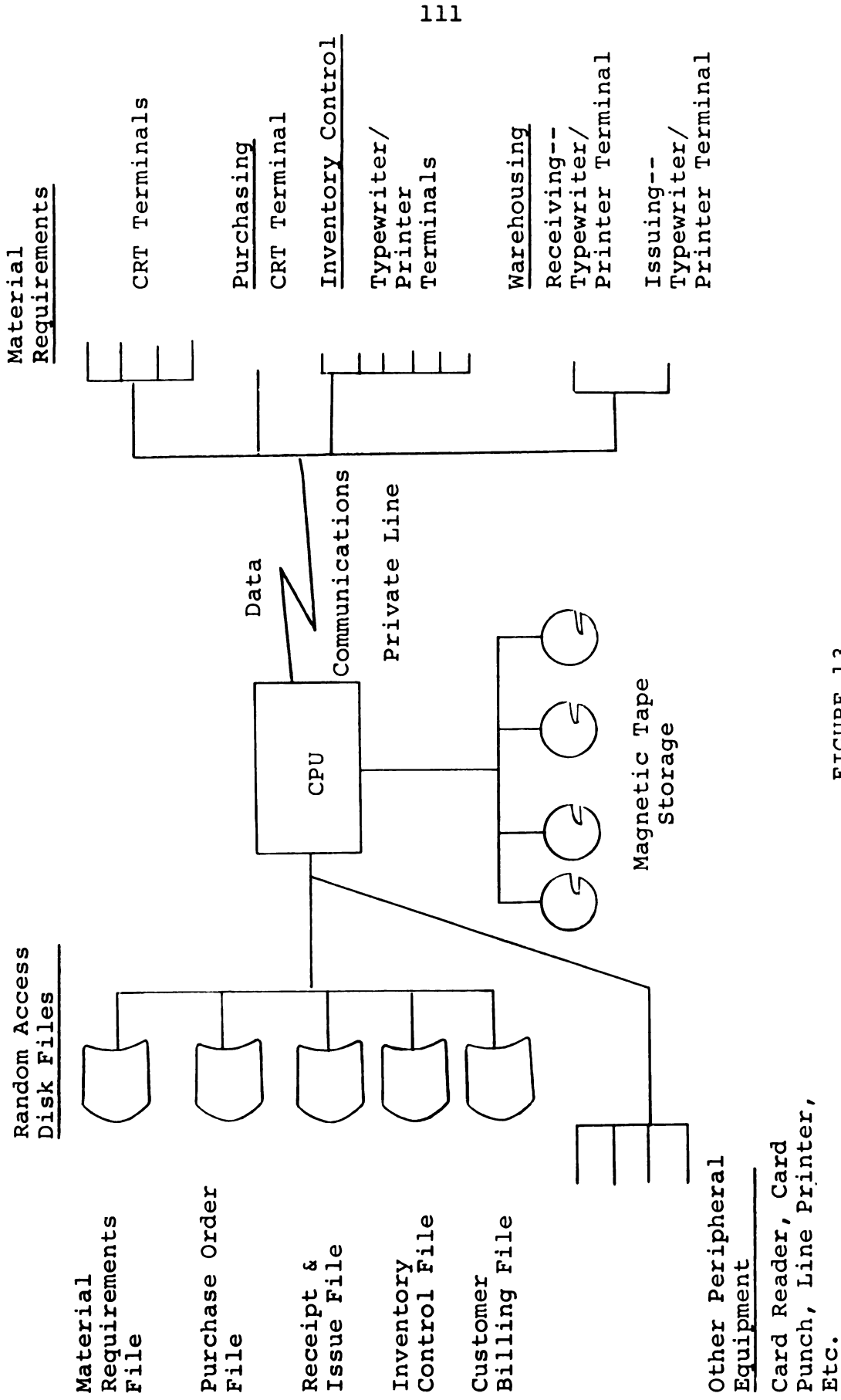


FIGURE 13

System 7--Space Propulsion Units and Parts Manufacturer

Major users of the system will be operating personnel in requirements, inventory control, purchasing and warehousing. Requirements personnel will estimate requirements from engineering data for various projects utilizing direct access capability to necessary data files. Inventory personnel will then utilize requirements data in their decision-making process regarding make or buy decisions and what quantities of purchased material and parts are required based on quick access to relevant data files. This group will then input data reflecting material needs to be acted on by purchasing and manufacturing.

The purchasing file can be used to obtain purchase order, part number, and supplier information and its input will reflect purchase conditions. The warehousing module will be used by operating personnel in determining location and availability of materials in receiving and receiving inspection. Upon receipt of incoming shipments, receiving data will be immediately input into the receiving and issuing file for use by personnel requiring such information. This input will also create an inspection and issuing document for parts and material release from the warehouse to manufacturing for use.

Considerable emphasis in development of the system has been placed upon managements' need to obtain current information regarding activities throughout the firm. This was because of the nature of the work environment which is

extremely dynamic with an emphasis on quality performance. Management cannot rely only on historical data. When a decision must be made, information regarding the latest activities must be readily available. Major use of terminals, though, in terms of time will be primarily by operating personnel, but direct access to a data base is required for management purposes.

A workable terminal to operating personnel ratio was thought to be between one and two operating people per terminal in material requirements and inventory control at the current work load volume. Initially this relationship would not be attainable due to economic constraints. Seven cathode-ray tube terminals will be installed in the material requirements section, fourteen typewriter/printer terminals in inventory control, one CRT immediately in purchasing and two typewriter/printers in the warehousing area assigned to receipt and issuance activities. The warehouse terminals appeared to be sufficient to support current volumes.

The system was primarily a real-time input-processing and real-time information retrieval system which is classified as a type D system. Furthermore, it was an unrestricted general purpose system which was internal to the firm.

Organizational control of the system was with the computer and data processing group. Development and implementation has been a mutual undertaking with using departments and data processing.

System 8--Academic Institution

The University of Illinois has implemented a time-shared information system for purchasing. It was operating on an experimental basis and therefore did not maintain all available data on random access files. The system, even in this stage of development, appeared to be a useful addition to the purchasing department.

Purchasing responsibilities included buying of materials and services except equipment, expediting, inventory control, transportation, and central receiving.

A large scale third generation computer system was used. Figure 14 depicts the system configuration. In addition to the central processing unit, the system included random access disk files, tape drives, card punch, card reader and other basic peripheral equipment. Terminal equipment consisted of a cathode-ray tube with data communications over a private line.

Time-shared system data files which were available to users were the pending requisitions file and the open purchase order status file. Other files available on tape will be put on disk at a later time. Data update was on a batch basis three times per week which reflected information a maximum of two days old. Information was then available in two formatted output displays.

Data update responsibility was centralized to gain advantages of specialization of labor in the data collection and input process. Documents reflecting purchasing

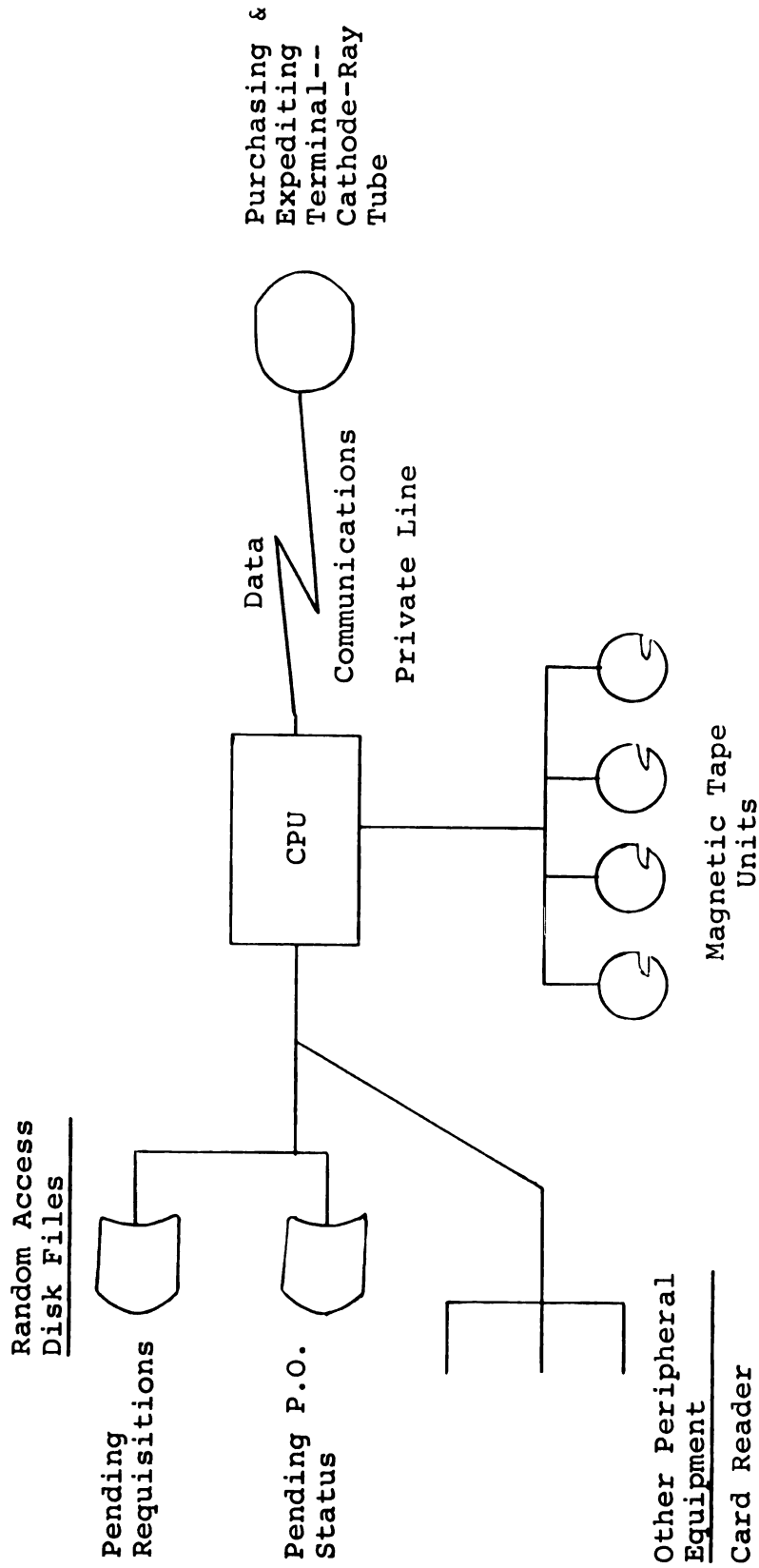


FIGURE 14

System 8--Academic Institution

activities were forwarded to this group and data was input to punched cards. The data was then transferred to tape and then to disk files for the pending requisition and open purchase order status files.

Users of the system were clerical, expediting, buying and management personnel. Location of the terminal was in the purchasing department. There was only one terminal available as the system was still experimental. Terminal use was on a job related basis with no formal security precautions.

The primary use of the time-shared purchasing information system was for buyers and expeditors to obtain information quickly in response to unstructured questions from requisitioners and management regarding payments, part order price information, and requisition status. The system enabled quick location of the current status in the buying parts and material flow process. Average response time to input questions was less than five seconds.

This system is classified as a type B system in the classification matrix. It was a batch input-processing, real-time information retrieval system with limited output capability. The computer system was an unrestricted general purpose system and internal to the organization.

Organizational control of the system and program maintenance responsibilities were shared by the administrative data processing and purchasing groups.

Analytical Applications of Time-Shared Systems

Time-shared information systems can be utilized for purchasing purposes other than planning and control directly related to material and parts flow. In addition, many other types of analyses indirectly related to materials management can be performed utilizing pure time-sharing systems.

The field research found that four of the firms visited were actively using such systems in purchasing related analyses. The following briefly explains the general types of analyses which were conducted.

Economic Order Quantity Determinations

Models were developed using company cost data for variables such as order processing cost and inventory carrying cost to assist in determination of the most favorable quantities to purchase reflecting market and cost conditions. These models were validated by utilizing historical data available in the data files on a sampling basis.

Learning Curve or Price Curve Analysis

This technique was being applied to various purchased commodities in an effort to forecast future prices. For example, technological development in certain industries follows a given general pattern thereby affecting selling prices in a predictable manner. Forecast future

requirements were considered against predictable price changes in conjunction with internal cost variables to predict optimum purchase points and predict product costs.

Buyer Performance Model

A model had been developed on a pure time-shared system which utilized specified buyer performance variables such as open purchase orders, items processed and a delivery index in conjunction with the exponential smoothing technique to indicate if significant variations were occurring in buyer activity. This model was then programmed for regular buyer performance output reports which were used by purchasing management.

Product Pricing Models

Examples were also seen of pure time-shared systems being used for product pricing. The general methodology followed in developing these models was that quantitative relationships were determined between variables such as purchased material and part cost, overhead, labor, etc., for various product classes. Ease of interaction with the computer enabled rapid experimentation to take place to obtain reasonable results which could be used for product pricing. These programs were then stored and could be continuously used for pricing purposes using changing cost data.

Opinions were expressed that more work could be done using the interactive capabilities of pure time-shared computer systems.

Synopsis of Major Data and Information
Input/Output Classifications

An analysis of data inputs and information which were available for retrieval indicated that certain elements were common to the purchasing and materials management time-shared information systems studied. The major data and information categories are presented using the following classification framework:

1. Requirements data and information: Detailed identification of materials and parts required to complete project or job objectives. Defined whether parts or materials were a manufacturing or procurement requirement.
Major data and information elements
Part Number
Engineering Level
Part Description
Major Model Used on or Project Identification
Next Higher Assembly
Quantity Required Per Assembly
Purchase or Make
2. Inventory and production control data and information: Related to material and parts on-hand,

on-order or required to meet established schedules. Schedules and quantity requirements must be determined for manufacturing and purchase requirements.

Major purchase related data and information elements

Part Number	Buyer
Part Description	Purchase Order Number
Engineering Change Level	Current Lead Time
On-Hand Quantity	Using Location
On-Hand Location	Usage Rates
On-Order Quantity	Inventory Class
Scheduled Shipment and Receiving Date	Maximum and Minimum Inventory Levels
	Supplier

3. Open purchase requisition and open purchase order data and information: Detailed information regarding purchase requisitions which have been issued but have not been placed and open purchase orders or those which have not been closed for a specified period of time.

Major data and information elements

Part Number	Purchase Order Number
Part Description	Purchase Order Placement Date
Engineering Level	Quantity Purchased
Purchase Requisition Number	Supplier Name, Address and Shipping Location

Purchase Requisition Issuance Date	Promise Shipment Date
Purchase Requisition Receival Date in Purchasing	Price
Purchase Requisition Issued By	FOB Point
Quantity Required	Terms of Payment
Required Date	Buyer
Using Location	Standard Cost
	Performance Information for Management
	Priority Rating

4. Vendor data and information: Pertinent facts
which pertained to current and past vendors.

Major data and information elements

Vendor Name	Union Contract Expi- ration Dates
Vendor Address	Payment Terms
Shipping Locations	Open Purchase Orders and Parts or Materials
Sales Offices	Dollar Volumes of Business
Representative	
Union Affiliations	

5. Part and material history data and information:
Retains important historical data concerning
parts and material.

Major data and information elements

Part Number	Part Description
Engineering Change History	Buyer
Price(s)	Standard Costs
Price/Quantity Com- bination Data	Vendor(s) Identifi- cation

6. Receiving and inspection data and information:

Identified parts and materials scheduled for arrival and movement through the firm to inventory, manufacturing, or returned to the supplier.

Major data and information elements

Part Number	Date Received
Part Description	Quantity Accepted or Rejected and Date
Receiving Control Number	Rejection Reason
Supplier Promise Date	Dock and Inspection Locations
Quantity Scheduled for Receipt	Disposition of Parts or Material
Quantity Received	

7. Transportation and accounting data and information: Detailed rate tables for analysis or best routing determination and provided accounting information required for invoice auditing, paying vendor accounts and financial control.

The elements discussed are data inputs for some areas and information for others. These elements can be used to develop any number of specific reports. Different report types which could be obtained via terminal were primarily related to:

1. Administrative processing activity completion in relation to program schedule requirements by operating personnel and department.

2. Cost comparisons of actual to standard or budget.
3. Incoming material and parts flow from suppliers meeting established standards related to time schedules, quality, and quantity.
4. Additional reports reflecting such considerations as operating personnel work loads, dollar commitments, concentration of purchases from various suppliers, and critical events such as supplier union contract expiration dates.

Chapter Summary

Field research was conducted with eight firms which were leaders in the design and development of purchasing and materials management information systems. Eight time-shared purchasing and materials management information systems were examined. These systems demonstrated the primary purposes for which such systems were being utilized.

A classification system was also developed which enabled categorization of the various time-shared information systems based on input-processing and output characteristics. Input-processing and output can each be either batch or real-time. Therefore, four primary types of systems are possible:

1. Batch input/processing--batch output
2. Batch input/processing--real-time output

3. Real-time input/processing--real-time output

4. Real-time input/processing--batch output.

Variations of these basic systems were also examined.

These systems aided in planning and control, especially at operational control levels. For example, in timely status determination of material received so that purchasing personnel could take corrective action when necessary, and in determination of on-hand inventory balances and purchase order placement for scheduling purposes. Purchasing and related documents were also directly prepared through the time-shared system.

In addition, although terminals were primarily used by operating personnel for operational control purposes, management would also use this information.

The number of terminals required for each location was determined by examining work load volume requirements in terms of available terminal time and economic considerations. Two to three personnel per terminal seemed to be a workable arrangement based on the experience of firms visited in purchasing, production, and inventory control areas. Fewer terminals were generally required in receiving areas and were directly related to the material and parts inflow.

Furthermore, all of the eight computer systems were internal to the firm. They were large scale third generation computers with random access disk and tape storage

and had compatability with a variety of terminals. Data communications were by both private and commercial lines. Two systems were dedicated and the others were unrestricted general purpose.

These time-shared information systems appeared to have demonstrated their feasibility in aiding in the planning and control process related to purchasing and materials management. Furthermore, utilization of time-shared systems for analytical applications such as economic order quantity determination and development of buyer work load prediction models were enthusiastically referred to by using companies.

A synopsis of major data and information input/output classifications was then presented.

CHAPTER IV

RESEARCH FINDINGS: TIME-SHARED INFORMATION SYSTEMS FOR PURCHASING-MATERIALS MANAGEMENT

Introduction

This chapter is a summary of the research findings regarding development and operation of time-shared information systems for purchasing and materials management.

Factors primarily examined in the field research were:

1. Major factors that affected a firm's decision to develop time-shared systems.
2. Time-shared system cost factors.
3. Time-shared system contributions to purchasing performance.
4. Major changes related to system development and operation.
5. Future time-shared system applications.

The findings are based on interviews with purchasing, materials management, and systems personnel at the firms visited and on internal documents provided by these firms.

Major Developmental Factors

The field research indicated that two major reasons were predominant in a firm's decision to develop time-shared information systems for purchasing and materials management. These were:

1. The firm was operating in a dynamic environment where conditions were rapidly changing and many different parts and materials were required.
2. A management philosophy existed which appeared oriented toward use of information system advancements for improved purchasing and materials management planning and control.

Easily measurable cost saving projections were not a primary reason for time-shared system development. The research further showed that all of the systems studied were internal to the using firm and that investment in current information systems can affect new system development. These factors will be discussed in detail.

Dynamic Environment

A situation which exemplified the affect of a dynamic environment on time-shared system development was seen at one firm. The complexity of the firm's operations increased significantly due to the addition of new product lines. Purchased part and material requirements were therefore expanded and planning and control problems related to parts and materials flow were becoming critical.

Management was forced to decide on a course of action to improve the situation.

The possibility of adding more manpower was examined and rejected. There was a need for timely and accurate information which was not obtainable by increasing the work force. Therefore, management approved the design and installation of a time-shared information system which could improve the planning and control of the purchased parts and materials flow.

A time-shared system was believed to be required because production lines could be shut down due to the inadequacy of available advance information regarding material and part shipments. The information time lag between establishment of a shipment schedule by suppliers and notification of this schedule being received by the buying firm was too long for smooth operations. Production schedules were often based on projected material and parts availabilities which were not realistic because of changing supplier shipment schedules. Or, certain product lines were not scheduled for production because information indicated that the necessary purchased parts and materials would not be available. In reality, though, they had become available because of improvement in supplier shipping schedules.

These constantly changing conditions created operating problems which led to the development of a time-shared system with direct data communications between suppliers and the purchasers. Shipment schedules and changes could

then be immediately provided to the purchasing organization for planning and control purposes.

Another example of a dynamic environment creating a need for a time-shared materials management information system existed with a prime contractor to the National Aeronautics and Space Administration. Accurate and timely information was extremely critical to successful operations at this firm. If there was a defective part problem at the Kennedy Space Center during a mission countdown, information had to be immediately available regarding location and availability of a replacement part to possibly prevent the mission from aborting which could be costly.

Furthermore, as was the case in the Apollo 13 moonshot where an explosion occurred in flight in April, 1970, it was of the utmost necessity to immediately obtain information regarding various aspects of parts and materials used in the flight. A realistic and rapid determination had to be made regarding the cause of the explosion and whether the next scheduled flight should continue as planned or be deferred. It became necessary to trace parts and materials to suppliers, to examine quality performance and to determine specific batches from which parts were used. Dynamic environmental factors such as these had led to the development of a time-shared information system for materials management purposes.

In fact, all the firms visited believed that dynamic environmental conditions were a significant consideration in

their decisions to design and develop time-shared information systems. Other examples of the environment contributing to time-shared system development were: behind schedule product conditions developing because of lack of current information, unstructured customer requests for accurate and timely information related to specific jobs, and source selection for large volumes of purchased parts and services.

Management Philosophy

The second most significant factor furthering development of these systems was a management philosophy, prevalent in all interviews, which was oriented to use of advanced computer-based information systems. Computer systems were considered a reliable means to improve purchasing and materials management performance. This philosophy and the environment were no doubt interrelated. Environmental forces can influence purchasing and material managers to further develop their information systems to adequately meet changing conditions.

Two examples illustrate this philosophy. In one case, the purchasing manager believed that a computer-based information system was required if the task of materials management was to be satisfactorily performed in the future. Because of this, efforts were made to determine the capabilities of computer technology and an investigation was conducted. It was decided, based on the computer technology

and projected benefits, that a time-shared information system should be developed for materials management. The system was installed and is providing projected and additional benefits. Furthermore, management is currently examining ways to extend system applications to obtain increased benefits.

In the second example, lower and middle purchasing management believed that a time-shared information system would be a valuable tool for purchasing personnel. Extensive computer-based purchasing information system files and applications were already developed and could be extended to the time-shared system. Terminals were obtained and through adaptation of a software package developed for use in another area of the firm, the system was operationalized. Top management was then apprised of this development and supported the system through a formalized program.

Cost Studies

As mentioned earlier, the research showed that measurable cost saving projections were not a primary reason for development of these systems. This was because the most significant potential cost savings were generally impossible or very difficult to forecast or measure and because of the overriding nature of environmental requirements. Examples of these undeterminable costs were, production downtime, lost business or increased purchase, and task coordination

costs due to an inadequate purchasing or materials management information system.

Total system development costs that were considered to be too high for a firm's resource limitations could, however, be a reason for not developing the system. For example, one firm believed that a pure time-shared system was required for improved purchasing performance. It was then determined that the total cost of such a system was beyond the current financial constraints of the firm. A decision was then made to develop a less costly time-share oriented system for which funds were available.

Internal Systems

All of the eight time-shared information systems used for purchasing and materials management were internal to the using firm. This can be explained by two factors. First, five of the eight organizations currently implementing or using these systems had large scale, third generation computers and software available prior to the development of the time-shared systems. Secondly, the other three organizations decided to purchase or lease computer systems because of internal data processing volume. Purchase or lease of a computer system was more economical when compared against costs of using a commercial time-sharing firm to provide the required services.

System Development

The research also indicated a difference in system development patterns between firms which were using a manual system and firms which were using a satisfactory computer-based information system prior to time-shared system design and implementation. Firms which converted from manual systems developed pure time-shared systems with browsing and programmed output capability while firms which converted from computer-based systems developed time-share oriented systems.

A comment often heard in situations where manual systems had been previously used was that "we analyzed what was required to accomplish the purchasing and materials management function and designed such a system." The manual processing and information systems were not considered in the same conceptual framework as the time-shared systems. Manual operations were not adequate to do the job and therefore they had to be replaced. In general, the manual systems did not limit design alternatives of the new automated systems.

The four firms which had prior computer-based information systems for purchasing and materials management developed time-share oriented systems which utilized a batch input-processing procedure. This suggested that: (1) pure time-shared systems were more costly than time-share oriented systems; (2) existing information systems could

preclude change due to the extensive time and effort required to alter the current system and possible disruptive effects on current operations; and (3) the time difference between daily batch and real-time input-processing may not provide significant benefits in some situations.

Summary

The considerations or factors that most significantly affected a firm's decision to design and implement time-shared systems were:

1. The nature of the operating environment.
2. Management philosophy.

Furthermore, cost factors were influential to some extent. All eight time-shared systems were internal to the firm and current information systems could affect the type of time-shared system developed. Four firms with prior manual systems developed pure time-shared systems and the four firms with prior automated systems developed time-share oriented systems.

System Cost Factors

The cost information related to time-shared systems, which was obtained from interviews and internal studies of the firms visited indicated the following:

1. Significant amounts of money can be spent on these systems.
2. They are more expensive than total batch systems.

3. Cost studies had been prepared which projected operating savings on an a priori basis by using firms.
4. Time-shared systems used purely for analytical applications with small data base storage were relatively inexpensive.

Cost data were not obtainable from every firm visited, either because the information was not available or the firm would not release it. This precluded a generalized cost/benefit analysis. Also, a common cost base for analysis did not appear to exist.

The cost of some systems can be demonstrated by examples which were typical in the firms from which cost data were obtained. Table 1 presents the approximate hardware costs of a medium size time-shared computer system.

The lease costs are total costs for each year of the lease based on a one or five year term. Furthermore, multiple magnetic tape drives, disk drives, and terminals were generally required which increased the cost. In addition to these costs would be systems development costs, programming costs and system maintenance costs.

A second example based on cost information provided by one of the firms indicates the general level of developmental and operating costs for a pure time-shared information system.

TABLE 1
Computer System Costs

Computer System Components	Purchase Price	Yearly Cost	
		1 Year Lease	5 Year Lease
Computer	\$220,000	\$ 54,000	\$32,400
Magnetic Tape Drive	27,000	7,800	6,600
Disk Drive	23,500	6,600	5,640
Card Reader	23,000	5,040	4,560
Line Printer	27,000	8,040	7,200
Card Punch	19,000	3,720	3,360
Cathode-ray Tube	3,500	840	840
Printer Station	8,400	3,060	2,760
Controllers:			
Display	14,500	3,120	2,880
Disk	25,000	6,480	5,820
Card Reader	12,000	2,820	2,520
Printer	23,000	6,480	5,460
Card Punch	24,300	5,160	4,680
Magnetic Tape	<u>21,000</u>	<u>5,340</u>	<u>4,800</u>
Total	\$471,200	\$118,500	\$89,520

Total information system operating costs per year	\$1,000,000
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Two year development costs--design and implementation	
Salaries--8 people @ \$15,000/year	\$240,000

Another firm estimated that its developmental costs including design, programming and checkout were approximately \$205,000 for a pure time-shared system. Additional operating expenses per year amounted to approximately \$450,000. These costs were significant and must be examined by firms planning to undertake development of such systems.

The above costs relate to pure time-shared system development from manual operations. Time-share oriented system development from a prior automated system would be less costly. Developmental costs related to necessary supervisory program software development could range from \$20,000 to \$25,000. In addition, assuming use of one disk pack, five CRT terminals and controller, data communication lines and a manufacturer supervisory program software package, approximate incremental costs to operate a time-share oriented system, over a similar batch system, could be from \$35,000 to \$40,000 per year. These costs will vary based on data volume. The actual computer was considered to be a fixed cost in this example.

Furthermore, time-shared information systems were more costly than batch systems. Estimates by firms interviewed indicated that the additional programming, disk storage, terminal and processing costs of time-shared

systems were approximately one and one-half to two times that of batch systems.

Cost studies were prepared by some firms that projected purchasing and materials management savings because of time-shared system implementation. These analyses were particular to individual firms and generalizations regarding savings were not developed because each firm began from a different base and had different volumes of business. The following are, however, illustrations of cost savings due to time-shared information systems.

One study projected a measurable yearly savings of approximately \$30,000 in total materials management and information system operating costs, in addition to providing other benefits such as improved customer support, on which dollar figures were not placed. Also, the cost saving and system developmental and operating cost elements which were used in the study and their percentage contribution to each category were:

<u>Cost Savings</u>		<u>New Costs</u>	
Personnel	- 22%	Developmental (one-time)	
		•Systems Design	- 6%
Mechanized System	- 31%	•Programming & Check-out	- 26%
Inventory	- 43%	Operating (Annual)	
		•Computer Operations	- 63%
Improved Procurement	- <u>4%</u>	•Remote Terminals	- <u>5%</u>
Total	100%	Total	100%

As stated, analysis of these cost elements showed a projection of an annual operating costs savings of \$30,000 per year, excluding developmental costs. If developmental

costs were allocated over the first year, there would be a cost increase of \$175,000. Furthermore, savings in inventory as significant as 43% of the total projected savings may not always be available depending on the capability of the prior system.

The research also demonstrated that increased costs and cost savings related to new system development and operation were difficult to isolate and measure. Firms often indicated that they did not have information available.

Utilization of time-shared systems for analytical purposes was found to be relatively inexpensive at the firms visited. For example, operation of an internal time-shared system for pure analysis cost one firm \$350 per month based on \$40 per hour for CPU time used, \$1.15 per 1,000 characters in disk storage per month and \$100 per month terminal rental costs.

Time-Shared System Benefits

Firms using time-shared systems for purchasing and materials management identified many contributions of these systems. The benefits were basically due to the timeliness, accuracy, and flexibility in obtaining information from the available data base.

Time-shared system benefits will be discussed under the following major headings:

1. Improved material and part flow into and through the firm.

2. Improved capability to react quickly to problem situations.
3. General administrative benefits and effects on personnel.
4. Analytical capabilities.

Improved Material and Part Flow Into and Through the Firm

Many examples of improved performance due to time-shared systems were provided by the firms visited. Timely and accurate information from these systems aided planning and control efforts.

One system provided production control personnel in the organization with timely information related to supplier advance shipment schedules and purchased part and material inventory status, thereby enabling improved production planning with fewer production disruptions and expensive last minute schedule changes. Status inquiries to suppliers were also reduced and less documentation was, therefore, required. In addition, purchasing personnel were often alerted to potential problems early enough to take corrective action with suppliers.

Additional benefits through use of time-shared systems were in the receiving and warehousing areas. Implementation of these systems facilitated a smoother flow through receiving and receiving inspection because of timely information regarding receipt of parts or materials. As

material or parts were received, they could be checked against purchase order requirements through direct access to the information system data base. There was no waiting time required to obtain purchase order information and therefore no need to store the material before it could be moved for inspection.

Elimination of waiting time reduced manpower and warehouse costs associated with storage at this location. Pilferage costs were also reduced because the parts and material were quickly moved to usage points or inventory areas which were generally more secure. Theoretically, inventory carrying levels would also be lower due to the reduced lead time required for parts or materials to reach using locations.

Also, one firm indicated that operation of time-shared systems could produce additional revenue for the firm. This firm reconditioned their used equipment which was then resold. If this piece of equipment moved through the reconditioning process one day faster than otherwise might be the case, a potential for added revenue existed.

A further benefit of time-shared systems was the on-line automatic preparation of receiving, inspection, and other required documents based on receiving input. Automatic document preparation improved the flow of parts and material through the system and reduced the need for clerical help.

Using firms also believed that it was easier to establish realistic task performance priorities which reflected changing operating conditions and do a better job of work load scheduling with time-shared systems. For example, if an item was critical to continuing manufacturing operations, this was immediately established in the data base by code. This information was then provided to the receiving area on automatically prepared receiving documents so that appropriate expediting action could be taken by receiving when parts of material arrived. Inspection would also schedule its personnel in accordance with the current delivery pattern.

Finally, development of time-shared systems tended to integrate the many materials management functions thereby reducing the possibility of redundant efforts by various groups doing the same task. This redundancy could occur because of limited information flow between the groups. For example, expediting of purchased parts from suppliers which was performed by both purchasing and production control because the current status of expediting action taken by one group was not known by the other.

Improved Capability to React Quickly to Problem Situations

Field research participants indicated that the ability to quickly react was a primary benefit to be gained from the use of time-shared information systems. Often a

need developed for information for operational or management control purposes which was not available on regularly produced reports. A data base, though, which could be queried in a timely manner provided the required information. Many examples of this contribution to purchasing and materials management performance were given.

One situation was presented whereby production could possibly be halted due to a postal strike. Purchase orders would not be received by suppliers and rapid identification was required of all purchase orders mailed in the last four days, to whom and supplier contact location. These suppliers could then be phoned and notified of purchase order placement and part and material required dates. The information was available within one-half hour due to the time-shared information system, which prevented possible problems on critical items.

Further benefits accrued because of general access to status information by operating and management personnel throughout the materials management system. For example, the number of inter-company and intra-company communications were reduced. Production control personnel queried the data base through terminals to determine part status rather than calling the buyer. Also, buyers would check the data base to see if material had been received rather than calling receiving or the supplier.

Traceability and quantity determination of parts and materials in the system also became an easier task as did the obtaining of past performance history. Furthermore, determination of realistic future courses of action based on timely availability of information regarding rapidly occurring events, as was pointed out earlier with respect to the Apollo moonshot, was also a significant contribution.

General Administrative Benefits
and Effects on Personnel

The following benefits were present in the firms visited:

- a. Reduction of the number of hard copy reports in the system because of CRT terminals when used with the time-shared system.
- b. Cost reduction related to the elimination of unused information by various personnel.
- c. Reduced data input error with pure time-shared systems due to on-line diagnostics and the individual seeing his data input.
- d. Less clerical search time required to obtain needed information from the time-shared system. It was estimated that search-time was one-fourth of the time required on hard copy reports.
- e. Improved visual ease of use, especially with CRT terminals.
- f. Less input required for automatic document preparation by use of codes and the data base to

provide the required information for automatic document preparation.

- g. Increased user confidence in a computer system and morale booster. This was a psychological factor referred to by some firms. Users were more impressed by time-shared systems, especially with CRT's than by masses of paper reports on a periodic basis.
- h. Increased status image of purchasing and materials management.
- i. Increased time available for important activities with reduction in clerical requirements.

Analytical Capabilities

The use of time-shared systems for analytical purposes has benefits. For example, the ability of the analyst and computer to interact on a problem solving basis, each complementing the strengths of the other. Furthermore, the ability to develop programs for various applications and rapidly reach solutions or test the effects of different values for variables in the model.

The following specific benefits were attained by the purchasing and materials management organizations visited which were using time-shared systems for pure analytical applications.

- a. Cost reduction due to the development and use of economic order quantity models which were not earlier used.
- b. Development of learning curve and price curve analysis models assisting in the forecasting of future prices in particular industries which improved buying decision-making.
- c. Development of buyer work load models which provided a standard for buyers to be measured against.
- d. Development of product pricing models which allowed experimentation to set a competitive price and incorporated all relevant costs including purchased parts and materials.
- e. Ability to quickly analyze and prepare timely reports regarding purchased parts and materials performance against established standard costs for project control.
- f. The ability to use actual operating data from the data base to validate models.
- g. The ability to quickly debug application programs which were later used in a batch system.

These applications were discussed in more detail in Chapter III.

It was the belief of many interviewed that additional benefits were available if firms would devote the time to develop analytical models.

In summary, enumeration of the many benefits provided purchasing and materials management by use of time-shared information systems substantiate the hypothesis of this study that "time-shared information systems can contribute to purchasing performance by providing required information for improved decision-making."

Major Changes

This section analyzes major changes associated with use of time-shared information systems for purchasing and materials management which were related to data base development, operating software program development, effects on system and procedures, organizational and individual adjustments by users, and system reliability.

Data Base Development

Interviewees were asked to comment on the effect that time-shared information systems have had on their data base and data collection record specifications to determine if development of this type of system was related to change or improvement in the purchasing-materials management data base.

The research showed that the data base was changed in those firms where manual systems were used prior to

development of the time-shared system. Firms which had used computer-based systems had not altered their data base structure even though the desirability to do so was mentioned. Changeover cost was the general reason for maintaining the same files. Total data base review and change of the firms which converted from manual systems provided the opportunity to eliminate irrelevant data elements currently in the system.

Software Development

An interview question was also used to determine who developed user operating programs for the time-shared systems. The results were that each of the firms had personnel knowledgeable in systems design, programming and implementation practices and procedures, and all system programs were developed internally. Three of the firms, though, did have some assistance from computer manufacturer representatives.

Systems personnel were located in both the purchasing-materials management and systems and data processing groups. Development of a pure time-shared system from a manual system generally required from one to two years and necessitated the services of experienced personnel. This suggested that firms undertaking development of these systems assure themselves of the services of capable and knowledgeable systems personnel.

Systems and Procedures

Implementation of time-shared systems altered purchasing and materials management systems and procedures related to task accomplishment in those firms where manual systems had been in prior use. In these firms, procedural changes were incorporated throughout the system.

Systems and procedures were not appreciably affected in the firms where computer-based information systems were previously used. The reason for change not occurring in this situation was because the method of information retrieval was the only element of the system that was altered. Generally, no effort was made to examine or change the total operating system.

Organization and Personnel

Organizational change occurred in some firms. For example, one organization reassigned all supplier expediting responsibilities to an expediting group which now had easy access to status information regarding purchases. These responsibilities had been previously assigned to buyers.

Another firm installed a time-shared information system which did not have to be used to perform the purchasing job. However, this was only the first step toward development of a time-shared system which would have to be used for job accomplishment. Therefore, if some personnel completely rejected using the current system, they were

being reassigned over time to other responsibilities that would not require use of the future system.

A further effect of a time-shared system on the organization was the necessity of a firm to reclassify positions. These positions were primarily clerical, and had newly associated responsibilities with direct computer system interaction. They were, therefore, considered to be at a higher level. Also, based on the field research, an individual's psychological ability to directly interact with computer systems may have to be given additional emphasis in future employee selection because the purchasing and materials management functions appear to be oriented to increased computer use.

Furthermore, time-shared system implementation required some adjustment by the individual users. They had to learn to use the system and what it could do for them. This necessitated educational programs which were undertaken in all firms. These programs varied from short instruction regarding data input and expected output, to computer programming instruction, to an overall approach. The latter included classroom discussion of the man-machine interface, closed circuit television instruction regarding the system and system operating documentation, and classroom computer programming lessons.

Educational programs were believed to be very important to the successful implementation of time-shared

systems as is also the case with other computer systems. The efforts required by learning personnel were often more stringent, though, due to the specific operational knowledge required to operate direct access information systems which use terminals.

System Reliability

A high performance level was required to maintain the confidence of users in time-shared systems. If a batch system had operating problems, it was unlikely that purchasing and materials management personnel would be aware of it unless output reports were affected. However, in the case of a time-shared system, a malfunction was quite obvious and affected all those who were using and needed to use the system. Confidence in the system can be seriously affected either by long or frequent down-time periods.

The research indicated that down-time did not appear to be a major problem once the systems were fully operational. Interviewees were all quite satisfied with system performance which was above the 95 per cent level. Any major problems that did occur were early in the system installation stage. Overall user response to the third-generation computer systems used for time-shared systems was very good.

Future Applications

Future time-shared system applications for purchasing and materials management which were foreseen were:

1. An extension of the time-shared systems to include additional files which were currently available on tape.
2. Elimination of all batch reports as the cost of random access disk storage decreases. Reports on a demand basis only through direct access with increased terminal installation and use.
3. Development of pure time-shared information systems for receiving if not currently available. This was considered very important and included automated receiving and associated document preparation.
4. Development of computer graphic programs enabling users to see performance relationship via graphics rather than numbers only.
5. Development of automated decision processes.
6. Direct order placement via time-shared system data communications to supplier terminals on "B" and "C" category inventory items when a minimum inventory level is reached.
7. Development of a paperless ordering system. Internal purchase order paperflow would be essentially eliminated by direct input of purchase agreement data to the time-shared information system.

8. Development of "demand work units" via the time-shared system. Task initiating forms, such as a purchase requisition, would be stripped down documents containing only the most basic information, or the same format displayed on a CRT terminal. Additional required information for task completion would then be requested from the system.

These applications were indications of future changes that may take place in purchasing and materials management operations which were using time-shared systems. In addition to providing timely information, the methods used in task accomplishment would change due to these systems.

Chapter Summary

Major factors affecting development of time-shared information systems for purchasing and materials management were the dynamic nature of the operating environment, management philosophy, and cost considerations to a lesser extent. The type of information system in use prior to time-shared system development can affect final system design. The time-shared systems in use were internal computer systems because it was more economic than using an outside commercial time-sharing service bureau. This was primarily due to large data storage requirements and the availability of internal hardware and software.

Cost information was difficult to obtain but did indicate that time-shared system costs were significant and were more than batch system costs.

Many contributions or benefits were due to time-shared information systems and were primarily related to:

1. Improved material and part flow into and through the firm.
2. Improved capability to react quickly to problem situations.
3. General administrative advantages and effects on personnel.
4. Analytical capabilities.

These findings supported the hypothesis of the study that "time-shared information systems can contribute to purchasing performance by providing required information for improved decision making."

Furthermore, major changes in a firm's data base were not found in purchasing and materials management organizations with automated systems prior to implementation of time-shared systems. Changes in the data base had occurred in those firms where a prior manual system was operational. User operating programs were developed internally. System and procedure changes were minimal except in firms converting from manual systems. Organizational effects of time-shared systems related to redelegation of authority, job reclassification, and possible review of selection procedures.

Future applications of time-shared systems for purchasing and materials management were then presented which could significantly change the methods of task accomplishment.

CHAPTER V

RESEARCH FINDINGS: COMMERCIAL TIME- SHARING FIRMS

Introduction

Time-shared information systems for purchasing and materials management can be developed using a computer system internal to the organization or, possibly, through use of services offered by commercial time-sharing firms. Seven commercial time-sharing firms were visited to obtain information regarding possible use of commercial systems for purchasing and materials management purposes. Interviews were conducted with systems and sales representatives using the interview guide in Appendix B. Published material was also obtained.

The firms visited offered time-sharing services in various locations throughout the United States and all except one were part of companies listed in The Fortune Directory of the 500 Largest United States Industrial Corporations.¹ In addition, although other commercial time-sharing organizations offered services, it was believed that

¹"The Fortune Directory: 500 Largest United States Industrial Corporations," Fortune, LVIII (May, 1970), pp. 184-200.

the seven firms could provide basic information necessary for purchasing and materials management to consider use of this type of service.

Major processing locations of the time-sharing firms varied from two to seven locations. The number of service offices which were available for customer use ranged from six to approximately eighty per firm. Commercial time-sharing service was generally available in industrialized sections of the country. The systems could be used according to the time schedule in Table 2.

All systems were available for use Monday through Friday from at least 8:00 A.M. to 6:00 P.M. Some systems were also in operation for longer time periods Monday through Friday and on Saturday and Sunday.

TABLE 2
Commercial Time-Sharing Hours of Operation

	Monday - Friday	Saturday	Sunday
Firm 1	7:00AM-11:00PM	7:00AM-11:00PM	7:00AM-11:00PM
Firm 2	24 Hours	to 4:00PM	Local Option
Firm 3	8:00AM-10:00PM	8:00AM-10:00PM	8:00AM-10:00PM
Firm 4	2:00AM-12:00PM	2:00AM-12:00PM	2:00AM-12:00PM
Firm 5	8:00AM- 8:00PM	8:00AM- 8:00PM	--
Firm 6	8:00AM-6:00PM	Option	Option
Firm 7	8:00AM-11:00PM	8:00AM-11:00PM	--

The companies all utilized large scale third generation computer equipment which had compatibility with various types of terminals including typewriter/printers and cathode-ray tubes. Compatibility of each system was limited, though, to certain terminals within the typewriter/printer and CRT categories. Data communication lines were generally provided by The Bell System. The commercial time-sharing firms would provide assistance in making arrangements to obtain communication line services and required equipment.

Furthermore, some commercial time-sharing firms were oriented primarily to scientific or to business applications. A particular orientation such as this could affect a firm's ability to assist in developing applications of one type or the other.

In addition to this general information, other specific objectives of the field research with commercial time-sharing firms were to acquire information concerning:

1. Purchasing-materials management application programs and general assistance provided by the commercial time-sharing firms.
2. Pricing structure.
3. Major user considerations.
4. Future commercial time-sharing application program trends.

Purchasing-Materials Management Application
Programs and General Assistance

Interviews and analysis of time-shared application program listings of the commercial time-sharing firms visited indicated that few of these application programs were directly developed for purchasing and materials management planning and control purposes. Application programs such as "Make-Lease-Buy" analysis and many statistical analyses were available which could possibly be utilized for specialized purchasing-materials management purposes.

One set of programs currently being developed for time-shared system use was a series of four programs concerned with:

1. Establishment and maintenance of an inventory level considered adequate to meet the needs of a firm through the testing of various inventory policies via simulation.
2. Calculation of economic order quantities and total acquisition costs over a given planning time horizon.
3. Determination of frequency and size of order placement with multiple price breaks.
4. Calculation of an optimum inventory level for as many as 350 different items where storage space is limited in terms of cubic feet.²

²Time-Sharing Tools for Inventory Control, Series 1 and 2, Field Test Draft, General Electric Information Service Department, 1969.

Time-shared data management programs have also been developed which have the capability to update and maintain records in a file, perform inquiry and information retrieval functions and prepare required reports. Four of the time-sharing firms had these programs. This type of capability could be used for purchasing and materials management planning and control similar to the systems described in Chapter III.

An application typical of data or file management capability was a group of two programs which provided file maintenance, inquiry, information retrieval and report generation capabilities.³ One program was a file maintenance program used to delete, alter, or add new records to an established file. Instructions regarding the exact operations to be performed were specified by the user via terminal in response to prompting questions from the computer during program execution.

The second program was used for record selection and output and was the means for accomplishment of information retrieval and report generation from the available data base. Individual records or complex reports could be obtained through use of this program.

All information output was specified by user criteria in the form of relational tests utilizing the following statements: EQUAL TO; NOT EQUAL TO; LESS THAN; GREATER

³MINIMIS Introduction (New York: Service Bureau Corporation, 1969).

THAN; NOT LESS THAN; or NOT GREATER THAN. Furthermore, multiple relationships could be used in requesting information through use of the "AND" statement and the "OR" statement.

The limited availability of application programs for time-shared system use which were related to purchasing-materials management prevented use of commercial systems without the development of required programs. A potential purchasing-materials management user of commercial time-sharing systems would have to ensure that necessary resources were available for this development.

All of the firms visited offered general assistance to users in the form of program library accessibility, classroom instruction, field technical assistance, instruction manuals, and occasionally a two to three day visit by a systems analyst.

The cost of this assistance was included in the major price elements. However, this policy could change if firms decided to identify all operational cost elements. Each service provided would then be charged for separately.

In addition, systems analysis personnel from some of the time-sharing firms were available on a fee basis for assistance in developing and operationalizing time-shared system applications.

In summary, there were very few "off the shelf" application programs of the commercial time-sharing firms

visited that were developed for and could be easily used by purchasing-materials management.

Pricing Structure

Pricing information for the services of commercial time-sharing firms is given in Table 3.

Examination of these prices showed some variation among the major cost elements of the time-sharing systems. The major differences occurred between costs associated with use of the central processing unit and on-line storage. For example, comparison between Systems 1 and 6 showed considerable variation in costs of these two elements. The cost of CPU time for System 1 was three times that of System 6 and the on-line storage cost of System 6 was more than two times greater than System 1.

The effects of these price differences on a using firm were dependent on the requirements of the using firm. Major requirements were the size of the data file maintained on-line and the use of CPU time. For example, if a firm were to maintain 5,000,000 characters in on-line data storage, the monthly cost would be \$1,269 if System 1 were used and \$3,026 if System 6 were used. A difference of \$1,757.

Furthermore, examination of CPU time used would show that if one hour per month were used, the total CPU and storage costs for Systems 1 and 6 would be \$1,809 and \$3,206, respectively. If five hours of CPU time were used,

TABLE 3

Commercial Time-Sharing Pricing Schedule

	Connect Time	CPU	On-Line Storage ^a
System 1	\$11.00 per hour	\$.15 per second	\$.26 per unit
System 2	\$10.00 per hour (1st 10) ^b \$ 8.50 per hour (next 40) ^b \$ 7.50 per hour (next 50) ^b \$ 6.50 per hour (all over 100) ^b \$ 5.00 per hour ^c	\$.04 per second	\$1.00 per unit
System 3	\$10.00 per hour	\$.03 per second	
System 4	\$10.00 per hour	\$.30 per CRUD	\$.50 per unit
System 5	\$10.00 per hour	\$.30 per CCUD	\$.90 per unit
		\$.10 per system second ^d	\$.24 per unit (0-100 units) \$24.00+\$2.16 per unit (101-1000 units) \$218.00+\$1.68 per unit (1001-5000 units) \$890.00+\$1.20 per unit (+5000 units)
System 6	\$10.00 per hour	\$.05 per second	\$.62 per unit
System 7	\$ 9.00 per hour	\$.50 per second ^e	\$.15 per unit

^aA unit equals 1024 characters (numbers or letters) and storage costs are on a per month basis.

^bPrime time: 9:30 A.M. to 12:00 P.M. and 1:30 P.M. to 4:00 P.M. daily, Monday through Friday.

^cNon-prime time.

^dSpecially designated units related but not directly to central processing time used.

^eSome variation by priority.

these same costs would be \$3,969 for System 1 and \$3,926 for System 6. Finally, if ten hours of CPU time were used, the CPU and on-line storage costs would be \$6,669 for System 1 and \$4,826 for System 6. Assuming approximately similar processing times, System 6 would be the least expensive of the two systems when five hours of CPU time were used.

Specific on-line storage and CPU time requirements of a using firm require determination before entering into a contract with a commercial time-sharing firm. Total cost can be significantly affected by the amount of on-line storage and use of the CPU. Processing times of different computer systems vary for the same job, though, also affecting total using costs of the different systems.

A firm considering use of a time-shared system for purchasing-materials management planning and control could have significant on-line storage costs. For example, a firm which maintained on-line 5,000 records of 800 characters each would require random-access space for 4,000,000 characters. This size of file was similar to some of the files of firms with operational time-shared systems.

The total number of units, of 1,024 characters each, required per month in this example would be 3,906 units. Using one of the lower on-line storage cost figures of \$.50 per unit, total yearly on-line storage cost of the 5,000 records would be \$23,436. If 10,000 records were maintained on-line, this cost would double or be \$46,872. In addition, the costs related to CPU utilization and terminal connect

time would increase the total costs. The significance of these costs make it necessary to examine on a continuing basis all system cost elements to determine if lease or purchase of a time-shared computer system would be most economic when compared to use of commercial time-sharing services.

Additional major costs of using a commercial time-sharing system were for terminals and data communications. The costs of obtaining a terminal varied significantly, from approximately \$85.00 per month to lease a basic type-writer/printer to thousands of dollars to purchase a cathode-ray tube terminal.⁴ Determination of specific uses to be made of the terminal, operating capabilities and compatibility with individual commercial time-sharing firms influenced the choice of a terminal for use.

Data communication costs were made up of such items as data sets, line costs, and conditioning costs for special high speed lines when required. Interviews with representatives of The Bell System indicated that there weren't "typical systems." Wide variations existed in all cost considerations. For example, there were different types of data sets with different capabilities ranging in price from \$25.00 to \$70.00 per month for lease. Also, data communication line prices varied from local dial-up service to

⁴"Data Display Equipment--Annual Reference Section," Business Automation, XVI (Sept., 1969), pp. 76-79.

intra-state service to inter-state service and for full duplex or half duplex lines.

These variations in data communications cost could be important for a multiplant firm establishing communication links between various locations. Generally, though, the problem was less complex if a commercial dial-up service to a commercial time-sharing firm were sufficient to hook into the commercial system. Primary concern was obtaining sufficient lines to be able to quickly reach the computer when needed. Average local dial-up cost per line was approximately \$10.

Data communication costs may not be significant proportionately for large data base systems but reliable service was required for a successful time-shared system.

Major Considerations for Users

Major considerations which confront potential and actual users of commercial time-sharing services are discussed in terms of the general set of tests established by Rullo. These tests were:

1. System availability--is the time-shared system available at the time and day which you require it?
2. Operational suitability--
 - a. Language--is the language availability suitable to your needs and can it be learned easily on a conversational basis?

- b. Application programs--what type of application programs are required for your operation and are they provided by the commercial time-sharing firm?
 - c. User assistance--exactly what type of assistance do you need and is it provided?
 - d. Special hardware--determine the type of terminal suited to your needs and eliminate those systems which cannot support the terminal.
- 3. Contractual suitability--is it possible to enter into an agreement which suits your needs? For example, a short-term agreement if you are just gaining knowledge as to the advisability of full utilization of time-shared systems.
 - 4. Benchmark tests--will the system support your type of operations in test runs?
 - 5. System load--is the system capable of adjusting to an increased work load or will performance suffer?
 - 6. Price structure.⁵

In addition to the initial determination of whether to use a commercial time-sharing firm or to develop an internal system, the decision to use a commercial time-

⁵Thomas Rullo, "Selecting a Time-Sharing Service," Data Processing Magazine, XVI (September, 1969), 76-79.

sharing firm necessitated choice of one firm in particular. This choice was dependent on a firm's specific purchasing-materials management needs such as type of application and data base requirements, and the ability of a particular time-sharing firm to best satisfy those needs.

The services offered by commercial time-sharing firms were examined using Rullo's outline.

1. System availability: all of the firms maintained service for the generally accepted working hours of 8:00 A.M. to 5:00 P.M., Monday through Friday. Weekend and late night time-shared system service was available at some of the firms. If purchasing-materials management needs were such that the system had to be available at varying times, the hours of system operation could be significant in the choice of a commercial time-sharing firm.
2. Operational suitability:
 - a. Languages: among the various computer programming languages available for use with commercial time-sharing systems were BASIC and FORTRAN. These programming languages were used on all of the systems. In addition, some of the other languages which could be used were SNOBOL, PL/I, PDPS, COBOL, ALGOL and a few unique to specific firms.

The availability of various programming languages for commercial time-sharing system use did not appear to be a problem for a purchasing-materials management group considering possible use of such systems.

BASIC and FORTRAN programming languages were the primary languages used in the operational systems described earlier and were satisfactory in situations where interactive programming was necessary.

The determination of specific time-shared applications by the user influenced choice of the exact language to be used. For example, if a skilled analyst were the primary user of the system and analytical work were being performed, FORTRAN would probably be used because it is oriented to scientific problem solving. If the purchasing-materials management users of the commercial time-sharing system were primarily personnel associated with the direct planning and control of parts and material flow, BASIC could be used because of its ease of learning and its comparability to the English language.

- b. Application programs: choice of a specific commercial time-sharing firm for purchasing-materials management use could also be influenced by their capability to provide application programs. For example, the ability to provide an analytical program for cost/price analysis or a data management program which was usable for planning and control of parts and material flow. The availability of standard programs which have been developed could save a using firm time and money.

Based on the firms visited, though, few standard programs for time-shared purchasing-materials management purposes had been developed. Limited availability of standard programs could reduce the significance of this factor in the choice of a commercial time-sharing firm. Development of the application programs would then have to be internal to the using company or possibly in conjunction with a time-sharing firm.

A differentiating factor in choosing a commercial time-sharing firm could then be the availability of personnel in their organization who were familiar and experienced in

the purchasing-materials management area. The field research indicated that these people were available in some of the organizations visited.

- c. User assistance: the type of assistance offered by commercial time-sharing firms could influence the decision to utilize one firm or another for purchasing-materials management purposes. For example, if a using firm required a training program in the basic fundamentals of terminal operation and a programming language, the commercial firm could be used to provide this service. The capability of various commercial firms to complete such a program would require examination.
- d. Special hardware: this factor could be significant in choosing a commercial time-sharing firm to provide services for purchasing-materials management. Needs in terms of a general type of terminal would be determined and then the compatibility of various commercial time-sharing systems with this type of terminal would be examined. For example, a purchasing department may decide to use a CRT terminal for their time-shared system applications. If a commercial

time-sharing firm's system was not compatible with this terminal, that time-sharing firm would be eliminated from consideration.

3. Contractual suitability: all possible contract arrangements require analysis. Investigation includes discussion of more than the generally offered contracts, especially if a using firm would produce significant revenue for the time-sharing firm. For example, on-line storage costs may be negotiable if certain volume levels of storage can be guaranteed.

Payment terms could also be discussed to determine the most advantageous terms available. These terms did vary by company. Furthermore, what legal binding clauses were associated with the various contracts offered by the different time-sharing firms? The objectives of a company using commercial services could influence the desired length of time the contract would cover. For example, if a firm were planning to test the use of a time-shared system in their purchasing operation on a limited basis prior to large scale internal system development, the firm would hesitate to enter into a long term agreement.

4. Benchmark tests: capability of particular systems to provide reliable and valid service requires system examination. The potential using firm could test the system's capability by processing actual company data for which results were known and comparing them with results from the commercial system. Testing was generally easier for analytical applications than it was for large data base applications because of the effort required to initially prepare and load data files on random access equipment.

Furthermore, commercial time-sharing system operation could also be tested by using available data in the commercial system to process certain applications. This approach would enable a possible user to determine if the system generally appeared to work the way it should. Also, other customers of the time-sharing firm could be contacted to determine possible problem areas and their overall attitudes regarding the system.

5. System load: could the system perform adequately to meet the needs of a using firm in the future with increasing or changing work loads. It was found that all of the commercial time-sharing firms had a maximum number of terminals

which could be used simultaneously, and if more were in operation, performance of the system would be adversely affected.

Information such as terminal capacity of the system, current load factor in terms of total terminals and future terminal projections could be obtained to analyze the future reliability of the system. These factors were important because time-shared systems require reliable system operation. If the time-shared system does not provide adequate service, users lose confidence in system's performance and obtain information through alternative channels, thereby wasting the resources associated with system development and operation.

6. Price structure: discussed in prior section.

In addition to these considerations, the research indicated that prospective users of a particular time-sharing firm also investigated the following:⁶

1. Security
2. Data loss prevention systems
3. File availability
4. Organization

⁶For additional details see, Alan G. Hammersmith, "Selecting a Vendor of Time-Shared Computer Services," Computers and Automation, XVII (October, 1968), 16-22.

Purchasing-materials management users of commercial time-sharing services would be concerned with the security of their data. Data stored on-line in commercial time-sharing systems required broad security measures to protect each user's data.

Examples of the types of security measures used by the commercial time-sharing firms visited were: assigned user identification numbers, the locking of certain data files into one mode such as "execute only," and the using firm assigning its own unique number series to prevent use of a file by others.

Data loss prevention procedures used by the commercial firms were concerned with minimizing potential data loss if a system malfunctioned. An example of a data loss protection procedure used by the firms visited was nightly transference of data files on random-access disk to tape and retention of the tape file for a period of time. This ensured that the maximum loss of data would be for one day's activities. The file reflecting a one day loss of data could then be recreated from original activity documents at the using firm. Other safeguards were oriented to the use of back-up computer systems and CPU capability preventing data destruction in file storage if there was a CPU malfunction.

Current and future file availability would also be important to a purchasing-materials management operation

planning to use a commercial time-sharing service. What is the maximum file size? Is it adequate to meet current and future purchasing-materials management data base requirements? It was found that large data files were available but were costly. For example, files holding more than 45,000,000 characters were available.

Finally various questions can be asked regarding the organization and operation of the commercial time-sharing firms being considered for possible use. For example, such factors as length of time in business, length of time hardware/software has been operational, financial backing and availability, number of computer centers, number and location of systems software people, support personnel, personnel turnover rate and reference manual clarity and accuracy can indicate whether a firm is effective and efficient in its operations.⁷

These and other considerations important to a purchasing-materials management operation can be used as criteria in the rating and selection of a commercial time-sharing service. The field research indicated, in general, that the firms visited did vary according to these criteria. For example, the financial backing and capability to obtain funds was significantly different for the firms as was the extent of their training programs.

⁷Ibid., p. 21.

Criteria such as these generally would be considered important in selection of a commercial firm to provide time-sharing services, especially with the rapid changes taking place in the commercial time-sharing industry.⁸ A using firm would not want to get involved in an unstable arrangement which could adversely affect their purchasing-materials management operations.

Future Trends

Additional objectives of the field research with commercial time-sharing firms were to determine future trends related to the development of purchasing-materials management application programs and possible technological advances which could influence the decision of purchasing-materials management to use or not use commercial time-sharing services.

All of the interviewees, except one, stated that their firms were increasing their development of business application programs for their time-shared systems. In fact, one firm which had been primarily oriented to scientific applications had set a goal of eventually having 40 per cent of their programs oriented to business applications. The general feeling was that the field for business applications had not been developed. These firms, though, could

⁸"Time-Share Shakeout Starting," Electronic News, January 26, 1970, p. 13.

not identify specific time-shared application program development for purchasing-materials management. However, some developmental work could have been progressing which the interviewee was not aware of.

The major reasons given for limited development of business and purchasing-materials management application programs were a lack of people knowledgeable in these functions and the difficulty in writing general programs which could be used by various users to meet specific needs. It was indicated that additional people familiar with these areas were now becoming available but that the difficulty of developing general application programs for specific needs was still a problem.

In addition, technological advances which were viewed as possibly increasing the utilization of commercial time-shared systems were lower storage costs due to the development of improved random access storage equipment, improved terminal capability and data communications, and continuing development of flexible programming languages.

Chapter Summary

Field research was conducted with seven commercial time-sharing firms and a data communications firm to obtain information regarding the availability of purchasing and materials management application programs, pricing structure of services offered, major considerations which potential users should be aware of and future trends.

Application programs which were directly related to purchasing-materials management operations were very limited. Some of the commercial time-sharing firms had general file management systems available which could be used for parts and material flow planning and control. Several time-shared inventory control application programs were also available.

The major cost elements of commercial time-sharing were costs associated with terminal connect time, CPU usage, data storage, terminals, and data communications. Comparisons were presented which showed the differences in some of these cost elements for various firms. Furthermore, data storage costs could be significant and could become the major cost element of using commercial time-sharing services for purchasing-materials management.

Major factors requiring consideration in selecting and using a commercial time-sharing firm were discussed. These were:

1. System availability
2. Operational suitability
 - a. Languages
 - b. Application programs
 - c. User assistance
 - d. Special hardware
3. Contractual suitability
4. Benchmark tests

5. System load
6. Security
7. Data loss prevention systems
8. File availability
9. Organization

The firms indicated that they were placing more emphasis on development of business applications. A problem slowing this development was the difficulty in designing general programs which could meet the specific needs of many firms. Technological advances such as improved random access storage equipment, terminals and more flexible programs would make use of commercial time-shared systems more economical and feasible for purchasing-materials management in the future.

CHAPTER VI

SUMMARY AND CONCLUSIONS

Summary

This study was made to provide new information on the use of time-shared information systems for purchasing and materials management.

The importance of purchasing-materials management to the success of an organization's profitability, changing computer system capabilities and the limited research related to this subject substantiated the need for such a study. The hypothesis of this research was that time-shared information systems can contribute to purchasing performance by providing required information for improved decision-making.

The review of published material included the areas of computer-based information systems, time-shared information systems and purchasing-materials management information systems. Basic information of value to the study was obtained from the literature review, but generalized research based findings of time-shared information systems for purchasing-materials management were not found.

Field research was conducted with eight organizations using or planning to use time-shared information systems for purchasing and materials management purposes, seven commercial time-sharing firms, two computer manufacturers, and a data communications firm.

The research findings based on the literature review and systems studied were discussed in Chapters II through V. These findings substantiated the hypothesis of the study (Chapter IV) and provided additional information which pertained to the research objectives discussed in Chapter I. Findings were related to: (1) the use of time-shared information systems for purchasing and materials management, and (2) the possible use of commercial time-sharing firms to provide time-shared system capability for purchasing and materials management. A general summary of the findings for which detailed information was presented in prior chapters is presented below.

Time-Shared System Use for Purchasing and Materials Management

Five categories are used in this section to present the summarized findings.

System Applications.--

1. Time-shared systems can contribute to purchasing and materials management performance by providing required information for improved decision-making.

These improvements were: (a) improved material and parts flow into and through the firm, (b) improved capability to react quickly to problem situations, (c) general administrative benefits and effects on personnel, and (d) improved analytical capabilities.

Examples of improved performance were cited in Chapter IV.

2. Development of time-shared systems for purchasing and materials management was primarily related to a dynamic operating environment and a management philosophy favorable to computer-based information systems. Cost savings were not a primary reason for time-shared system implementation. Furthermore, many benefits of these systems were evaluated in qualitative terms.

A dynamic environment was characterized by rapid change in conditions involving large numbers of basic activities such as purchase order placement.

3. Time-shared system applications were developed for planning and control purposes related to:
(a) buying, (b) inbound transportation,

(c) purchased part and material inventory control, (d) receiving and receiving inspection, and (e) production control.

A synopsis of major data and information input/output classifications was presented for each application area. In addition, analytical applications which were seen were discussed in Chapter III.

4. Time-shared system applications in purchasing-materials management operations first appeared to be implemented in areas offering the greatest potential for improved performance to a specific firm. For example, applications were often first established for the planning and control of basic purchase activities such as vendor selection and purchase order placement, for inventory control, and for the receiving operation.
5. A firm which developed time-shared systems for purchasing-materials management was confronted with many alternatives in terms of time and frequency of data input, possible combinations of information output and format, and types of computer equipment and terminals to be used. Analysis unique to each situation was required

to determine the system characteristics best suited to meet the needs of a particular firm.

6. Top management support and educational programs were generally required to ensure the overall success of these systems. Top management support was required for the expenditure of funds and to direct the efforts of appropriate personnel to achieve working systems.

Educational programs were necessary to familiarize and train personnel in the use of the direct man-machine computer systems which required use of terminals and often, the definition of information requirements by computer programming statements.

7. Operational personnel were the primary users of the time-shared systems for purchasing and materials management.

Design and development.--

1. System design and development of pure time-shared systems generally required from one to two years. This process required the availability of personnel knowledgeable in systems design and development and in the functional areas for which applications were developed.

2. Systems and purchasing-materials management groups worked closely in the design and development of time-shared systems. The success of many of these systems was partially attributed to this close working relationship. Neither group generally had complete knowledge in both areas but complimented the other in their efforts.
3. Pure time-shared information systems for material and part flow planning and control were generally costly to design, implement, and operate. Two important factors influencing cost were number and type of applications. Data regarding costs were presented in Chapter IV.
4. Time-share oriented information systems were less costly than pure time-shared information systems and were considered adequate for the needs of a number of firms.
5. Time-shared systems for material and parts flow planning and control, and for analytical applications were separated for system design purposes. Both types of applications, though, were used in a complimentary manner when possible. For example, systems were designed where material and parts flow data could be input to analytical models for analysis.

6. The cost associated with using a time-shared information system for analytical applications was relatively inexpensive both on an internal basis and when using the services of a commercial time-sharing firm.
7. Firms with manual purchasing and materials management systems prior to time-shared system development had considerable flexibility in the design and development of time-shared systems to meet their specific needs. These firms generally developed pure time-shared systems.
8. Firms with satisfactorily operating computer-based purchasing and materials management information systems, prior to development of time-shared systems, were somewhat constrained in developmental alternatives. This was generally due to a large investment in earlier systems and changeover problems which could affect operations. These firms developed time-share oriented systems.
9. Application programs for time-shared systems were primarily developed by the using firms because of the availability of personnel and lack of commercial application programs.
10. Data input responsibility was generally centralized in each functional area to ensure

data base accuracy. This often necessitated the establishment of restricted terminals with output capability only and others with both input and output capability.

Major changes.--

1. Time-shared systems appeared to further coordination between functions in purchasing or materials management groups. Personnel in these various functional areas had accessibility to timely information related to overall activities.
2. Time-shared information system implementation can influence reorganization of purchasing-materials management responsibilities. For example, a purchasing expediting function was centralized in one of the organizations visited because of the availability of easily accessible and timely information.
3. Increased use of time-shared systems could require the establishment of employee selection techniques to identify prospective personnel who could have difficulty directly interacting with a computer system. The need for adequate selection criteria would be significant in situations where the use of time-shared systems was required for task accomplishment.

4. Purchasing and materials management personnel were, in general, more favorable to obtaining information from a terminal than from hard copy reports. Furthermore, personnel were favorably impressed by the capability of the time-shared systems and did not want to return to the "old" way of doing things.
5. Purchasing and materials management procedures and data bases were relatively unchanged when firms converted from established computer-based information systems to time-shared systems. Significant changes occurred in the data base and procedures when time-shared systems were implemented from a manual base.

Computer Systems.--

1. Current computer technology appeared adequate to support the operation of time-shared information systems for purchasing and materials management. Occasional operational problems would develop but systems were operational more than 95 per cent of possible use time. Minimization of down-time and its frequency were critical to the successful operation of time-shared systems because users were directly involved with the system.

2. Firms with operational time-shared systems had large investments in computer equipment and computer system personnel, both in the systems and data processing group and the purchasing-materials management group. These firms had the necessary resources available to undertake innovative systems design and development work which appeared to be successful.
3. Third generation computer systems were used for time-shared applications which could be related to high operating performance.

Future use.--

1. Time-shared systems were being considered for additional applications. Their success in current applications has led to further analysis regarding the possibility of expanded use.
2. Future time-shared system applications could eliminate much of the current paperwork in purchasing and materials management systems. Also, use of time-shared systems with data communications between buying and selling firms could enable improved planning and control of material and parts flow between and through these firms.
3. Additional analytical models could be used to examine the effects of interactions in the

purchasing-materials management system and for analysis of external environmental factors to improve purchasing-materials management performance.

Use of Commercial Time-Shared Systems

The following summarizes the field research with commercial time-sharing firms:

1. Commercial time-sharing systems were and could be used for purchasing and materials management purposes. These systems were currently most feasible for analytical and other applications requiring "small" on-line data storage because of the storage cost. Purchase or lease of internal computer systems was the most economical course of action if "large" on-line data storage was required at commercial time-sharing firms.
2. A limited number of commercial time-shared application programs were available for purchasing and materials management use. Purchasing and materials management application programs would have to be developed by, or under the direction of, the using firm.
3. A significant increase in the number of commercially available time-shared application programs for purchasing-materials management

was not foreseen in the near future. The major deterrents to this development were indicated to be the lack of people knowledgeable in these applications and the difficulty encountered in writing general programs to meet the specific needs of many individual firms.

4. Installation and operation of commercial time-sharing systems for analytical purposes appeared relatively easy.
5. Choice of a specific commercial time-sharing firm was based on a number of factors related to a firm's needs which were discussed in Chapter V.
6. Future use of commercial time-shared systems appeared more attractive because of computer technology advances such as random access storage equipment which can contain more data at lower cost, and faster, cheaper terminals.

Conclusions

The findings of this study point to several conclusions regarding the use of time-shared information systems in an important area of business activity:

1. Time-shared information systems have broad application potential in purchasing and materials management departments.
2. The use of time-shared information systems for purchasing and materials management will

probably increase in business and other organizations because of the benefits of these systems, increasing competition and improving computer technology.

3. Careful analysis of individual operating situations is required to determine time-shared system applications which will benefit the firm.
4. Time-shared systems probably improve coordination of the various functions in purchasing or materials management groups because of easy access to timely information.
5. Time-shared systems could change the manner in which purchasing and materials management activities are completed.
6. Increased analytical application of time-shared systems will probably be made for purchasing-materials management.

Due to the operational successes of time-shared systems for purchasing and materials management, and increasing awareness of their capabilities, additional emphasis undoubtedly will be placed on examining their potential use by various firms. Detailed information has been presented in prior chapters of this study and it is hoped that this information will be of use to those with time-shared information systems and those considering their future use.

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APPENDICES

APPENDIX A

"TIME-SHARED INFORMATION SYSTEMS FOR
PURCHASING" INTERVIEW GUIDE

APPENDIX A

"TIME-SHARED INFORMATION SYSTEMS FOR PURCHASING" INTERVIEW GUIDE

Background

1. Company Name:
2. Division:
3. Address:
4. Interview Date:
5. Person Interviewed:
Name: Position:

Purchasing Applications and Data Requirements

1. What current purchasing applications are time-shared information systems being used for?
2. What are the data input-output requirements of these applications?
3. Who has responsibility for providing the required data?
4. What future purchasing applications do you foresee?
5. What activities is purchasing responsible for?

Policy manuals and job descriptions were obtained where possible.

Time-Shared System Contributions

1. What contributions to purchasing performance have been due to the time-shared system?
2. What future contributions do you foresee?

Feasibility Study Factors

1. What factors entered into purchasing management's decision to utilize a time-shared information system?
2. Is the operating system internal to the firm or are commercial facilities used?
3. What factors entered into purchasing management's decision to develop internal or external capability?

Feasibility studies were obtained where possible.

Major Problems or Changes

1. Were any problems or changes encountered in the data base requirements with development of a time-shared system?
2. Who developed the user operating programs for the system and what problems were encountered?
3. What type of purchasing information system was in use prior to the time-shared system and what effects did this development have on your systems and procedures?
4. What future changes do you foresee?

The Time-Shared Computer System

1. Who, organizationally, has control of the system?
2. How are the costs of operating the system determined?
3. What type of cost allocation procedure is used?
4. What are the costs of operating the system?
5. What type of time-shared computer system is used?
 - a. Central Processing Unit?
 - b. Input/Output Equipment?
 - c. Storage Equipment?
 - d. Terminal Equipment?
 - e. Data Communications?
 - f. Other?
6. How many remote input/output devices are used?
7. Where are they located?

8. Who has access to them?
9. What is the average response time (at 80%-100% usage)?
10. What problems do you encounter with technical operation of the system?

APPENDIX B

COMMERCIAL TIME-SHARING INTERVIEW GUIDE

APPENDIX B

COMMERCIAL TIME-SHARING INTERVIEW GUIDE

Background

1. Company:
2. Address:
3. Interview Date:
4. Person Interviewed:
5. Position:
6. Number of processing locations and location:
7. How many service offices does your firm maintain:
8. When is your system operational:
Days:
Hours:
9. Is your firm scientific or business applications oriented?

The Operating System

1. What type hardware components does your time-shared system consist of?
 - a. Central Processing Unit:
 - b. Storage Equipment:
 - c. Input/Output Equipment:
 - d. Terminal Compatability:
 - e. Data Communications:
 - f. Other:
2. What are the pricing elements that make up the cost of utilizing your system?
 - a. Central Processing Unit Time:
 - b. Connect Time:
 - c. Storage:
 - d. Input/Output Equipment:
 - e. Terminals:
 - f. Data Communications:
 - g. Separate Phone Charge:
 - h. Minimum Charge:
 - i. Other:

3. What is the average response time of your system (80%-100% utilization)?
4. What are the outstanding operating characteristics of your system?
5. What computer programming languages can be used?
6. What type of on-line reliability do you provide the user?
7. What data loss protection does your system have?
8. What type of security system is in operation?
9. What information retrieval and analytical application programs does your firm have available for users?
10. Does your firm have any user programs specifically designed for purchasing applications?
11. Are you aware of the development of general business application programs and/or specific purchasing application programs?
12. What are the major problems in such development?
13. What assistance programs do you have available for your system users?
14. What are the major problems in utilizing your system?

Use and Development of Commercial Time-Sharing

1. What are the major considerations that a firm should examine in deciding whether to utilize commercial time-sharing facilities?

2. What are the major advantages of a firm using a commercial time-shared system versus a batch-processing system?
3. What technical and service improvements do you foresee in commercial time-sharing?
4. What are your future forecasts regarding business oriented use of commercial time-sharing facilities?
5. How is the commercial time-sharing industry and your firm preparing for forecasted business application developments?