Library Trends

Systems Design and Analysis for Libraries

F. Wilfrid Lancaster
Issue Editor

April, 1973
# Library Trends

**Volume 21 • Number 4**  
**April, 1973**

## Systems Design and Analysis for Libraries

**F. Wilfrid Lancaster**  
*Issue Editor*

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Introduction

F. WILFRID LANCASTER

The planning of this issue proved much more difficult than I expected when I first accepted the assignment. The major problem was to arrive at some meaningful subdivision of the field of systems analysis and design as it relates to libraries. A division by type of library—public, academic, special—did not seem particularly useful, nor did a division by type of library activity studied—acquisitions, circulation, serial control, and so on. Instead I have tried to gather contributions representing a roughly evolutionary approach to systems analysis and design in libraries, and also representing the subject from various viewpoints. Systems analysis in this issue is treated as a management tool in its own right and not merely as a necessary prerequisite to a program for library automation. This broad concept of systems analysis involves, as Mackenzie puts it later in the issue, “seeking out the fundamentals of a situation, and applying to their study rigorous scientific methods, with the aim of finding an optimal solution to the problems facing the manager.”

Fasana defines systems analysis and discusses its components, uses and limitations in library applications. Chapman discusses the subject from the viewpoint of the library director and is primarily concerned with the tasks involved in planning a systems study, including the problems of appointing staff to such a study. Mackenzie’s viewpoint is also that of the library director, but his emphasis is on the use of systems analysis in the decision-making process. Special reference is made to the use of models of library activities in the overall systems analysis program. Mackenzie’s interpretation of the scope of systems analysis is much broader than that of many of the other contributors; he regards it as essentially indistinguishable from operations research.

Carter approaches the topic from the viewpoint of the systems ana-
lyst who is also a librarian (a somewhat rare and valuable combination!), and her contribution specifically relates to the use of systems analysis as a prelude to automation. Heinritz goes beyond analysis as such into the evaluation of library procedures, with special reference to the tools of “scientific management.”

The next three contributions deal more directly with design of new systems rather than analysis of existing systems. Corey and Bellomy discuss requirements for a new system (i.e., the requirements analysis phase of a complete program), while Minder describes procedures for designing a system to meet specified requirements, and Griffin deals with problems involved in implementing a new system.

Leimkuhler and Duchesne tackle special aspects of analysis, the former dealing with the analysis of libraries as large scale systems, and the latter with the analysis of library costs and performance. Duchesne proposes a library management information system which provides “budget, cost and performance data for planning and control purposes in addition to conventional financial and statistical statements.”

A certain amount of overlap and repetition appears inevitable in a collection of this kind, but I have tried to keep duplication to a minimum. The contributors are quite varied in their backgrounds and experience, and they represent a number of different points of view. They all agree, however, that a systematic approach is essential in the analysis and evaluation of existing services and the planning, design and implementation of services in the future.
There seems to be little doubt in anyone's mind that libraries are in trouble and have been for quite some time. Opinion as to how critical the problem is varies. There are those who feel that it is a matter of survival, while others maintain that it is simply a period of adjustment. Greater diversity of opinion exists as to the primary cause or causes. In addition, a shift has occurred in the nature of the causes cited. During the 1960s, for example, the most frequently cited causes were:

1. The changing structure of knowledge and the rapid development of interdisciplinary fields of study;
2. The information explosion and the phenomenal growth in the amount and kind of material published; and
3. The proliferation of new libraries and the increase in size and complexity of older libraries.

The 1970s, although still relatively young, have introduced a new set of causes, including:

1. Library management or, more precisely, the lack of librarians with basic management training;
2. The economic recession which has forced libraries to become conscious of such concepts as cost effectiveness and tight budgets;
3. The need to make libraries more immediately responsive to the changing needs of their users; and
4. The application of newly developing technologies such as computers, telecommunications, etc., to library procedures.

All of the factors mentioned contribute to the problem; none, however, is the basic or primary cause. At best each is a symptom, and solutions that address themselves to symptoms, such as simply increasing library budgets to buy more books and hire more librarians, or using comput-
ers to do what has been done in the past faster and more accurately, do not solve the problem.

The basic problem confronting libraries is the impact of rapidly accelerating change on an institution which has traditionally been slow moving and conservative. This problem is not unique to libraries; every sector of society has been affected. Any solution, therefore, must first attempt to understand the nature of change and then to develop a methodology to control and direct change.⁶

Systems analysis is a management tool that has proved valuable in analyzing complex organizations and has been used successfully in business, industry, government, and defense in identifying and solving problems resulting from organizations in conflict with an environment dominated by change and the uncertainty that inevitably accompanies change.⁷ The use of systems analysis in libraries to date has been limited. Increasingly, however, as can be seen by the professional literature,⁸ libraries are becoming aware of the potential usefulness of systems analysis to analyze and help solve their problems.⁹

Systems analysis is not a solution in itself. At best, it is a methodology, technique, or tool that has promise. If properly used, it can help librarians to identify the essential or real problems confronting libraries, to analyze pertinent factors, to develop alternative courses of action for consideration, and, finally, to implement more efficient systems.

WHAT IS SYSTEMS ANALYSIS?

A concise, generally accepted definition of systems analysis does not exist. Systems analysis is still emerging as a discipline. Aside from agreeing that systems analysis is related to management science and has borrowed heavily from several of its branches, there is little agreement among practitioners of systems analysis as to what it includes, where its boundaries should be drawn, or how it will develop. Perhaps the best way of understanding what systems analysis is, is to distinguish it from the closely related branches of management science from which it has developed. (See Additional References.)

Early in the twentieth century, the discipline of scientific management was developed. The primary purpose of scientific management was to determine faster and better methods of production. Little consideration was given, however, to the effect that these techniques had on workers or the effect that a specific operation might have on related operations, or the system as a whole. These limitations have proved
Systems Analysis

critical. During the past fifty years scientific management has spawned a number of related disciplines such as work measurement, methods research and work simplification, each of which suffers to some degree from the same limitations as management science—the emphasis on quantitative observation, and analysis of relatively isolated operations. Systems analysis employs many of the same techniques, such as time and motion studies, forms analysis and procedure charting, but uses the results for entirely different purposes and thereby avoids the inherent limitations of scientific management. Systems analysis is concerned with systematically analyzing a total system in context and in identifying and describing the interrelatedness of all the component parts or operations of the overall system. It attempts to measure not the effectiveness of a single operation or a narrowly focused set of operations, but the effectiveness of the system as a whole relative to the stated objectives and restraints of the parent organization.

Another major and more recent field of study is operations research. For practical purposes, some maintain that operations research and systems analysis are synonymous, but differences do exist and are increasingly significant. Operations research is an art or technique which uses the scientific method to analyze operational problems, and then to develop abstract models to predict how a system or set of operations is affected by changed or changing circumstances. Operations research relies heavily on the use of advanced mathematical techniques and computer simulation. Its purpose is to provide management with a quantitative basis for making decisions. Operations research does not, however, attempt to implement decisions by developing new systems. Its purpose is primarily to analyze, forecast, and recommend alternatives to management. By contrast, one of the basic objectives of systems analysis is the design, implementation, and evaluation of new and more efficient systems.

Systems analysis is not simply a collection of these older techniques, but rather is a discipline which is presently attempting to synthesize previous theories and branches of management science into a new discipline. The precise scope that this new discipline will take is still ambiguous. To the more enthusiastic, the direction is clearly towards subsuming all of management science within systems analysis; to the more conservative, the direction is towards defining systems analysis in terms of an attitude or approach appropriate for management to assume, enhanced by a corpus or repertoire of clearly defined and controlled analytical techniques.
Systems analysis represents a way of looking at and analyzing complex organizations and describing them in essentially quantitative terms. Its first objective is to encompass the total system of operations, from management's stated objectives and the resources available (i.e., personnel, material, etc.) to achieve objectives, to the needs of users of the system and the environment in which the system exists. Once a systematic, quantitative picture of the total system has been achieved, systems analysis turns its attention to relating (but not evaluating) objectives and results. It does this initially in primarily quantitative terms (e.g., the unit cost of cataloging a book, the time lapse between placing an order and receiving a book) and then consults with management to determine system effectiveness and efficiency. The evaluative aspect of this effort is a shared responsibility of the technically-oriented systems analyst and management, and produces a qualitative evaluation of the system being considered.

If the system is judged inefficient and problems are identified (as is usually the case), management then may authorize the systems analyst to continue and to develop alternatives that might be more efficient. This is undertaken, however, only with the expressed instruction of management. The systems analyst designs alternative procedures which meet the requirements of the system and presents them to management for consideration. Management should then evaluate the alternatives and make a decision. If the decision is to accept one of the proposed alternatives, the systems analyst is instructed to design, test, and implement the new or revised system.

The role of the systems analyst is to work with management, not to replace or usurp management. It is critical during a systems study to be aware of the appropriate roles of management and systems personnel, and to distinguish between them. It is essential for management to embody a systems attitude or approach, but it is even more important for management to preserve intact its responsibility to control and decide. In contrast, the role of the systems analyst is to provide technical expertise and support. The failure to distinguish the roles of management and systems personnel can result in severe operational problems.

**USES OF SYSTEMS ANALYSIS**

The uses to which systems analysis and the systems approach can be put in libraries are many and have yet to be fully identified or realized.
Systems Analysis

Following are several examples of how systems analysis can be of use to librarians. (See Additional References for literature dealing with application.)

Library Objectives—Librarians have often been accused of fuzzy, undisciplined thinking. The accusation, unfortunately, is too often true. The quantitative techniques used, the rigorous attention to detail, and the critical examination of facts, characteristic of systems analysis, encourage and enforce systematic, disciplined thinking about operations and organization. Such a critical, analytical attitude is fundamental to modern management and is an essential first step in understanding complex problems. For example, the objectives of an organization should be the starting point in the identification of problems and the evaluation of an organization. Objectives should be clearly stated and reflect a realistic attitude on the part of management. Too often library objectives are ambiguous, out of date, or unrealistic. Ask a librarian what he or she considers to be the objectives of the library and, too often, the reply is couched in platitudinous terms such as “providing service.” Service to whom? Service of what sort? User requirements for libraries have changed radically during the past twenty years, and the importance of information in our society has increased enormously. Yet, library objectives, resources, and techniques have changed little.

Unless objectives are stated explicitly, it is impossible to develop measures of performance. Unless effective performance can be demonstrated, it is difficult to justify continued levels of financial support and impossible to argue for increased support to provide new or additional services. The ability to demonstrate effective performance assumes critical importance in a period of economic recession. Increasingly libraries are being forced to enter an unfamiliar area where funds are limited and competition for these funds is sharp.

Library Management—Undisciplined thinking is also reflected in many library operations. It is not uncommon to find that operations in libraries have no reason for continuing. They exist because no one has questioned or evaluated them. Continual evaluation and modification of procedures is required to reflect current, changing needs. This requires a querying, analytical attitude on the part of librarians at all levels. Similar problems exist in the areas of planning, control, and decision-making. As organizations grow, the number and kinds of decisions that must be made proliferate and the consequences of these decisions become more critical. For example, a seemingly simple decision about
what information to include on an acquisitions order form can have profound effect on cataloging operations. Unless a librarian can analyze the nature of a decision and have facts available in a form that he can understand and use, he is forced to rely on personal experience and intuition which is often insufficient to meet the needs of modern organizations. Decisions based on fact and proper analysis, coupled with intuition and experience, are inevitably more consistent, realistic, and reliable.

Modern Technology—The ability to analyze and understand problems is critical and important, but the solution to many current library problems is beyond the capability of simple manual techniques. The increasing requirements of volume of material and the growing diversity of operations in libraries require that libraries, if they hope to survive and continue to grow, must begin to adapt and use the new technologies that are available. The successful implementation and use of a new technology is complex and costly. The use of computers in libraries is a good case in point. Although libraries have been experimenting with the use of computers for more than fifteen years, the proper role of the computer in libraries is still not adequately understood or defined.

Library automation has demonstrated that libraries will need a great deal of special technical assistance in designing and planning systems using new technologies. This assistance can be provided in part by using trained technicians and specialists from other disciplines. Controlling and coordinating these nonlibrary specialists is difficult, but highly essential, because the system that will be developed will ultimately have to be taken over and operated by librarians. The need, therefore, for librarians to gain experience and some level of expertise in systems analysis to guide the design and development of automated systems and then to operate them is becoming increasingly critical.

In summary, the key to any approach for improving library systems is the acknowledgement that systems exist to attain objectives. Systems exist in a changing environment and must be responsive to the realities of that environment. Systems analysis is a methodology especially designed to facilitate the continuing adjustment of a system to its environment. It does this directly by providing techniques which help to define realistic objectives and evaluate operations; indirectly, it develops a systems attitude or approach in its practitioners which is the essential base of good management.
LIMITATIONS OF SYSTEMS ANALYSIS

Systems analysis has a great potential use in libraries. One should not, however, overlook its limitations. Following are several examples of the limitations of systems analysis. (See the Additional References for sources which discuss these limitations.)

Qualitative Factors—Systems analysis at present is an art based on rather gross, primarily quantitative techniques. Applying quantitative techniques to institutions which produce tangible products and profits is one thing; attempting to apply the same techniques to a service organization, such as a library, is quite different. Precise measures of public service activities are difficult, perhaps impossible, to develop. Until (or unless) these quantitative techniques are refined to a point where they can take into account subtle, qualitative factors, such as user satisfaction, quality of cataloging, and effectiveness of selection policies, the main use of systems analysis in libraries will be limited to areas of processing activities, such as ordering and receipt of materials, and physical aspects of cataloging.

Management—Systems analysis purports to be a rational, totally objective approach to the analysis of operations and problem solving. It is not. The systems analyst uses his judgment and intuition in deciding which facts to gather, how to interpret them, and what alternatives should be developed for consideration. Management must be aware of this and be prepared to deal with the problems that may result. Systems analysis does not make management’s decision-making process easier; if anything, it makes the process more difficult. Systems analysis attempts to provide management with data to assist management in making better and more consistent decisions. It does not (or at least should not) assume management’s prerogative for making decisions. Too often by default, the systems analyst is forced to fill a vacuum created by management’s inability or unwillingness to make decisions. The proper role for the systems analyst is to advise and recommend, not to command and make management decisions.

Change—Ironically, systems analysis itself is affected adversely by change, the very force for which it was developed. A detailed, formal systems study will usually accumulate a great deal of data which often requires considerable time to assemble and analyze. The result of a systems effort is analogous to a snapshot which reflects or represents real-
ity at a point in time. Observations that are valid or correct at one point in time may be totally incorrect at a later date.

Cost—A full-scale, formal systems study is costly, often disruptive, and time-consuming. Unless there is sufficient promise that an effort will result in savings that are commensurate with the effort, a formal systems effort should probably not be undertaken. Unfortunately, it is difficult to know this in advance. The only factors that seem to be helpful in deciding whether to undertake a full systems study are scale and cost of operations. The larger and more costly an operation, the more likely that a systems study will prove beneficial. This should not be interpreted to mean that smaller operations cannot benefit from systems analysis. A staff experienced in the systems approach to operations and problems can do a great deal to increase the efficiency of their system.

**WHAT IS DONE IN A SYSTEMS EFFORT**

A full-scale, formal systems study will involve a variety of personnel, the number and type of which changes as the effort progresses. The actual work in a systems effort is normally done by a group of five or six technical specialists organized as a project team, headed by a project leader directly responsible to top-level management. Members of the project team are selected on the basis of anticipated needs of the project. If the object of the project is to explore the feasibility of using computers in cataloging, for example, the team would be made up of cataloging librarians, analysts, and computer programmers.

There are approximately six phases or steps in a systems study which can be distinguished, and in theory should be done in sequence; in fact, the process is iterative and overlapping. Usually, a specific problem or area of investigation is defined and becomes the focus of the project effort. However, the objective of an effort might be phrased in terms of the overall analysis of an organization to identify problem areas, each of which in turn would become the focus of a separate effort to be worked on in sequence or simultaneously, depending on priority and the number of personnel available.

The following section contains a brief description of the kinds of work done and the types of decisions necessary in each step of a systems study.

**Preliminary Study**—A formal systems effort begins with a decision by top management that a study is needed, followed by the selection and authorization of a person (or persons) to undertake the effort. Ideally,
the personnel selected should have experience with systems analysis techniques and some familiarity with the organization.

A primary purpose of the preliminary study is to get a broad overview of the entire organization, and this can be done in a variety of ways. One approach is to determine the objectives of the organization as phrased by top management, as interpreted and implemented by supervisors, and as understood by line personnel. This can be done by interviewing selected personnel at various levels and reviewing available documentation (e.g., annual reports, procedures manuals, etc.). Usually, revealing differences are uncovered between the objectives of top management and their actual implementation by line personnel.

The result of this overview should be a written report prepared by the analyst for top management which attempts to compare (or relate) management's objectives and systems performance, to identify major problem areas, and to formulate recommendations and priorities as to what should be done. Management then evaluates the report and decides on a course of action. If the decision is to go ahead, the analyst proceeds to define, plan, and estimate the requirements of the project effort for review and evaluation by management. Again, management must decide whether to accept, modify, or reject the analyst's project plan. If the decision is to proceed, management formally authorizes the project and approves the needed resources (i.e., money, personnel, space, etc.) to accomplish the project. The analyst is now ready to assemble a project team and initiate work.

The Descriptive Phase—The purpose of the descriptive phase is to gather data describing and measuring all aspects of current operations. There are a variety of techniques available to do this. Among the simpler and more effective are inventory and analysis of files, forms, and procedures, and flow charting of materials, data, and work flows. The descriptive phase is usually long and tedious, and produces a mass of raw data to be analyzed and used in later phases.

The Analysis Phase—The purpose of the analysis phase is to analyze the raw data that has been gathered, to assemble and display it in a useful form, and to begin to identify and compare alternate ways of accomplishing the same results. The techniques available to analyze raw, descriptive data are many and include, for example, sampling, linear programming and simulation. One of the more useful and easier to understand is modeling. A model is an abstract or symbolic representation of an operation or group of related operations. Models can be extremely sophisticated and use advanced mathematical theories and
computer simulation techniques, or they can be simple block diagrams which can be manipulated and evaluated manually. The purpose of a model is to predict how a set of procedures, real or proposed, works under varying conditions. Models are useful in evaluating a single system, predicting critical problem areas, and in comparing alternative systems designs.

Design and Development Phase—There are two purposes of this phase of work. The first is to prepare a detailed systems proposal, including work schedules, development and operating costs, equipment requirements, etc., of one or more alternate systems. The second is to develop, test, and document all aspects of a working system for implementation.

As a result of the analytical phase, the project team will recommend that the existing system be modified or, possibly, that a totally new system be designed. In either case, the team prepares a proposal documenting all aspects of the effort. If more than one solution or design is proposed, the same level of detailed documentation is required for each proposed alternative.

Management at this point reviews the project proposal and decides either to accept one of the proposed alternatives or to reject them all. If an alternative meets management’s requirements and is selected, the project can then proceed with the development of a full-scale, working version of the proposed system. This will include writing and testing computer programs (if required), preparing detailed procedure documentation, ordering equipment, preparing position descriptions, etc. In addition to developing the new system, plans for phasing out the old system should also be developed. In certain situations, this can be almost as complex, time-consuming, and costly as the total effort expended to design a totally new system.

The Implementation Phase—Eventually, the new system will be ready to be implemented, or “turned on.” Implementation planning is subtle, complex, and critical. Even an ideal system will falter and possibly fail if implemented improperly. The key to successful implementation is the creation of a hospitable environment. Unfortunately, there is no simple, infallible way of knowing if and when such an environment has been achieved. One of the more critical factors is staff attitude and acceptance. All staff should be trained, involved, and positively disposed to accepting and using the new system. This is done in part by conducting briefing and training sessions, which should be continued until
everyone understands not only how the new system works but what his particular responsibility or role in the new system is.

In addition, demonstrations of the new system should be undertaken. This is especially important if computer routines are being introduced. Systems demonstration is important in building confidence in new procedures and can take the form of a full-scale, parallel operation that may have to be continued for an extended period of time. Parallel operations are costly and cumbersome, but are necessary until everyone involved feels confident and familiar with the new system.

Other problems to be considered during the implementation phase include file conversion, if necessary, systematic phase-out of old procedures, site preparation, follow-up on training, updating of documentation, etc.

Evaluation and Feedback—A systems effort does not stop once implementation has been accomplished, regardless of how successful. Once implemented, a system must be monitored, evaluated, and modified. This is a continuing effort, especially if the new system is complex and uses computer processing to any degree.

Normally, the project team will initiate and carry out an overall evaluation of the new system, comparing performance with objectives. Depending on the complexity of the new system, extensive or minor modification of the new system may be made. Once completed, the full project team is no longer needed and can be disbanded. Responsibility for operating the new system now falls mainly on the operating staff.

In some instances, regular staff must be augmented by one or more technical systems persons. Computer-based systems, for example, may require that one or more programmers be employed on a continuing basis to modify applications programs to accommodate subsequent releases of computer-operating systems, to repair systems "bugs" and problems, etc. In less complex systems, the responsibility for systems evaluation and maintenance can take the form of a critical systems attitude on the part of the operating staff itself.

As can be inferred from the brief review of the various phases of a formal systems study, systems work is complex, dynamic, costly, and time-consuming, and results can never be guaranteed. (For more literature on this subject see the Additional References.) To date, most large scale systems studies in libraries have been done to develop and implement automated procedures. This does not mean, however, that systems analysis can only be used to design and develop automated
Systems analysis can and should be used in any situation where there is a need to measure performance and a reasonable possibility of being able to develop more efficient routines. Increasingly, systems analysis is being used by librarians in other areas of library activity, such as budgeting and management.

Systems analysis has already proved useful in libraries, first by fostering a critical, systems approach to operations and problems and, secondly, by providing libraries with new techniques useful in analyzing, evaluating, and understanding library operations. The future for systems analysis in libraries is promising, but will not be realized without effort on the part of librarians. Since systems analysis is an emerging discipline developed primarily for use in nonservice environments, the techniques currently available will have to be evaluated and adapted before they can be applied indiscriminately to libraries. This will take time and considerable effort.14

Perhaps the most useful contribution that systems analysis will make to libraries in the immediate future will be in the areas of management, organization, and adaptation to change. There is a potential danger, however, that librarians should be aware of. Systems analysis is a methodology which is very much involved with the management process. Its proper role should be that of assisting management to understand operations and to make decisions. It is a tool or extension of management and, therefore, must be controlled by management and not allowed to control or replace management.15

References

Systems Analysis


ADDITIONAL REFERENCES

BRANCHES OF MANAGEMENT SCIENCE RELATED TO SYSTEMS MANAGEMENT


LIBRARY APPLICATIONS OF SYSTEMS ANALYSIS


APRIL, 1973
Paul J. Fasana


Limits of Systems Analysis

Systems Study Components
Planning for Systems Study
and Systems Development

EDWARD A. CHAPMAN

The causes of increased complexities in libraries may be epitomized as: (1) the increased quantity and sophistication of the demands of library users; (2) the substantial increases in book funds; (3) the increase in interinstitutional cooperation; and (4) the frequent inability of professional staff to realize the professional potential for creative endeavor which may be traceable to a greater extent than known to the many manhours misused in clerical functions. A systems study or analysis is indispensible when a library faces these problems and admits that it is no longer serving its community effectively.

Systems study is equated to the phrase "let's get organized." It is prerequisite to a well-designed and successful automated system. Study methods and techniques can and should be used in analyzing, evaluating and designing all levels of data processing. The librarian familiar with the concepts and techniques of systems study and planning should be able to increase the efficiency and productivity of the library even if the only available mechanical equipment is the typewriter.

SYSTEMS STUDY CONCEPT

The systems study or systems analysis is defined as the logical analysis of the present systems; the evaluation of the efficiency, economy, accuracy, productivity and timeliness of existing methods and procedures measured against the established goals of the library; and the design of new methods and procedures or modification of existing methods and procedures to improve the flow of information through the systems.

The main distinction between the analysis and design phases is that analysis is a rigorously controlled inquiry into existing conditions, while

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APRIL, 1973
design is the resulting synthesizing process in which new ideas are generated and refined. Design is the final phase of a systems study involving creative thinking, coordination of the conclusions reached in the analysis, and deductive reasoning directed toward realization of the stated objectives and goals of management.

The concept of systems study consists of three interdependent phases:

1. Analysis, which is the accurate delineation of the requirements placed on a system; the current procedures by which the requirements are met; the outputs of the system in satisfaction of the system's requirements; and the inputs used to generate the outputs. The four items under analysis represent concurrent identification of the areas of inquiry, coupled with the charting of all operations, functions, decisions, and action, the gathering of data produced and forms used, the listing and evaluation of available personnel and equipment, all synthesized into a report of existing conditions.

2. Evaluation, which is the detailed examination of current procedures with respect to their adequacy to supplement the mission of the system.

3. Design, which is the action taken by validation of the existing system, by modification of it, or by substitution of a newly designed system to satisfy the demands being placed on the system. The problems to be solved and the techniques employed in designing systems are well stated by Ackoff.¹

Systems study and planning for improved operations are inextricably intermeshed activities. Problem recognition is the prelude to systems analysis and the development of plans for desired ends. Systems analysis is indeed the basis of effective planning to reach operational goals. Such analysis supplies the means of validating the efficacy of plans: Do they work as envisioned or projected? Thus systems study or analysis is the mechanism of planning efforts and plans' testing.

DEFINITION OF TERMS

The use of terms in detailing phases of a systems study can be a source of confusion. It is the intention here to avoid technical language as much as possible in order to serve better the understanding of the nonspecialist. The simple terms chosen are applicable to processing by any means, manual or machine, and can be expanded or modified where appropriate. It is suggested that the following terms are commonly in use and therefore can be helpful in effective interchange of ideas with management specialists. The arrangement of the terms attempts to indicate their logical and hierarchal interrelationships.
Goals: the objectives of the total system that establish demands placed against each component system and its subsystems and "whose attainment is desired by a specified time." Demand: the established requirements of a system and its subsystems.

Requirements: the supply of data, information, action taken resulting from a demand.

Input: the printed form, written record, oral information, or instructions needed to satisfy a requirement.

Output: the answer to the requirement of a system in the form necessary to convey or transmit information.

Subsystem: a major part, component, or activity of a system.

Operations: the major, specific units of work.

Procedures: used synonymously with operations.

Jobs: used synonymously with operations and procedures.

Elements of operations: the functions, decisions and actions comprising operations.

Functions: the processing steps in operations.

Decisions: the determination of the steps to be taken to complete a function.

Action: the course taken as a result of the decision.

LIBRARIANS AND THE SYSTEMS STUDY

Essential to the success of any study to effect operating improvements in a system is the interest, participation, and committed involvement of all members of the professional staff, managerial and nonmanagerial, as well as all personnel responsible for major, specific units of work. The systems study must be done by the organization itself, not done for it, if the study is to be successful. Lacking in-house expertise in study techniques, outside support should be obtained for on-the-job training of the library's personnel. In order to consolidate the gains that can come from a systems study, the personnel must be capable of maintaining surveillance of the recommended operational structure and procedures. As indicated, the principal requirement here is complete staff involvement in the analysis and planning leading to redesigned operations.

A systems study is the beginning of a different administrative and organizational work pattern that must be monitored in order to maintain and improve the library's ability to achieve the goals set for it. The study is not directed toward producing an end-for-all plan but for ini-
tiating an on-going process of operational evolution and improvement as demands placed against the library change. Continuous analysis and evaluation of current methods and procedures should insure that the demands for information and action being placed on the systems are being met. If they are not, the design and modification of methods and procedures become necessary.

Thus it would appear desirable for a library to have on its administrative staff at least one full-time staff officer whose responsibility is that of continuous guidance and assistance in the improvement of systems and procedures, problem anticipation, and modification of processes and procedures as demands or requirements placed on the organization change. The size of a library is not a factor in the need for systems study. In the case of the one-man library it would be left for the librarian himself to acquire the requisite management study skills. Medium-to-large-sized library organizations might well think in terms of full-time staff specialists.

Since this “systems analyst” or “manager of systems and procedures” is a staff officer, established and accepted as an agent of the library’s director, this point of view and interest must be coterminous with those of the director. He should have or acquire a full and broad understanding of management’s problems and should be involved in the director’s decision-making sessions. The responsibilities of this position, in cooperation with library department heads, include the following functions.

1. Assisting management in the review and evaluation of operations and services to meet the established goals of the library.
2. Designing and implementing, in cooperation with supervisory staff, new or improved operating systems for increasing effectiveness, strengthening operating or management controls, and expediting performance of routine work.
3. Developing operating manuals and reviewing, improving, and planning statistical and accounting reports for managerial control at all levels.
4. Evaluating existing forms and, as necessary, designing new or improved forms.
5. Conducting training programs for staff management in the regular application of systems study techniques to daily operating problems and in the capabilities and use of the computer in operations and library services.
6. Directing the design and programming of computer-based systems, representing the library’s interests in shared computer facilities and avoiding the many errors that can occur during introduction of such
systems. (Bernstein discusses twelve principles "which absolutely must be applied during the introduction of a mechanised system.")

7. Keeping abreast of new developments in data processing, together with associated equipment, and their potential application in library operations.

The responsibilities of this type of position, well established in the business world, are listed in considerable detail in Neuschel as well as in other management texts.

Library systems analysis, evaluation, and design will be ineffectual unless done by persons who are trained or formally educated in librarianship. Although without experience, the library school graduate is prepared to learn the nuances of library service that can only be gained through experience. At least his schooling has made him aware of this contingency and he is prepared to develop professional attitudes. This cannot be safely said of one trained solely in managerial techniques.

Many library schools are beginning to recognize the need for an introduction to systems study and data processing. A survey of thirteen selected library schools during 1972 revealed that ten were offering courses, for which course outlines were submitted, in library systems analysis and data processing. Wasserman suggests that the library school should offer programs in these subjects to the practicing librarian at an intermediate level, "not necessarily tied to any formal degree offering, although some type of certificate mid-way between the master's and doctorate might be devised." Conversely it is suggested that programs in the specific functions of the control systems of a library be offered to management degree holders. This is being done by some libraries through inservice study programs. In institutions where both a library degree and a management degree are offered, an interdisciplinary program could be profitable in making available to libraries management personnel knowledgeable in library operations.

LIBRARY MANAGEMENT AND THE SYSTEMS STUDY

Modern library management, aware of the need for systems study, has no recourse but to learn the techniques and tools of systems analysis and the skills to apply them—the basis of good management. If a library is to examine itself with the techniques of management science, the responsible personnel should be trained to do so.

Because systems study represents a demanding total library effort that may result in major operating changes, the entire library staff—administrative, professional and unit management—under the strong lead-
ership of the library's chief executive, should be fully involved in planning and conducting the study. Thus everyone at every level of responsibility is forced to review and gain detailed understanding of the problems and objectives of his operations, from the least significant organizational unit through top management. Here the guidance, direction and personal participation of the chief executive of the library are critical.

All authorities in management science agree that the chief executive is responsible for the proper execution of the study and its results. This is not to say that he personally does all the study planning, but rather he sees that it gets done through key second level people who are responsible for implementation of the study plans. The chief executive's primary task is that of leading in the identification of study objectives, and of reviewing, accepting, approving and authorizing implementation of each element of the study plan. Reasons why the chief decision-making executive should assume primary planning responsibility are explored extensively by St. Thomas. To control the quality of the outcome of the study: (1) top management must take a positive rather than "a passive, problem-solving approach"; and (2) the study program should be planned and developed with a total systems approach.

The questions usually uppermost in the chief executive's mind in approaching systems analysis and planning are: (1) What are the systems problems that should be solved in relation to organizational goals? (2) Can these problems be resolved by redesign of operations and procedures? and (3) Will the redesigned systems be operationally accepted by the personnel responsible for implementing them? Answers to these broad questions obviously require the help of key administrative and line staff. An advisory committee consisting of the chief executive as chairman, second level management and selected staff people is suggested. Regarded as workable is a membership of six to eight supplemented from time to time by individuals who can supply specific experience, information or knowledge needed to confirm or fill in certain planning elements. The chief executive should chair at least a majority of the meetings of the committee if he is to assure his colleagues of his positive, problem-solving interest. He should have a specific agenda for orderly evolution of meetings. The committee's overall objective is to develop the information and data for a written statement of the organization's goals and the unit operational problems it sees preventing achievement of these goals. Such a written statement is the...
document needed by the systems analysts assigned to probe for solutions of the stated problems.

It appears axiomatic among management authorities that “when the top executives are not personally engaged in the process, it can be doomed from the start.”20 Many of the reasons for failure of study programs revolve around management: (1) the study is not integrated into the total management system; (2) it is not recognized as a way of managerial living; (3) line management at all levels is not engaged in the process; and (4) management fails to operate by the plan.21

Although assessment of the techniques and methods of a proposed program of systems study is of concern to management, this is not nearly as important as the designation of study elements appropriate to organizational goals and objectives.22 Continuous monitoring of the study through required interim reports will or will not reveal progress in the direction of decision-making information needed in coming to solutions in systems problems selected by management. The only criterion, if the study procedures are not tending to yield the required decision-making data, is to stop and seek revision of procedures. Otherwise the study will reach faulty conclusions of no use to management’s requirements.

**STUDY STAFF**

Having decided or received governing administrative authorization to proceed with the detailed systems study based upon the preliminary findings of the advisory committee discussed above, the chief executive or library director selects and appoints the staff to make the study. The principles to be observed here are: (1) the assignment to the study staff must be clear and precise in written form and not given verbally; (2) the study staff must be given sufficient time to develop procedures for execution of the assignment;23 (3) a good systems study cannot be done on a part-time basis; and (4) the person selected to direct the study preferably should possess a combination of education in librarianship and training in the methods of systems analysis as taught in modern management courses. Since satisfaction of the latter prerequisite probably is not possible in most instances, two courses are open: to release a senior or general-manager level staff member from other duties to prepare himself for the conduct of a study, or to bring in a skilled systems analyst unfamiliar with the library’s organization. The latter course holds the danger that the library staff may tend to abro-
gate their responsibilities in the study to the outside expert. Should this occur, then the systems study "has been given the kiss of death."\textsuperscript{24}

The outside analyst skilled in modern management techniques should become fully familiar with the library's problems and responsibilities. He should develop a rapport and identification particularly with management personnel at all levels in order to insure supervisory acceptance and cooperation in the analytic procedures of the study. He should not approach the study with preconceived notions of the local problems to be solved, possibly arising from his work with another library or with what he feels is an analogous organization. Although the conditions he sees in a cursory inspection may appear to be the same as he has encountered before, the causes of the conditions to be studied frequently are completely different. The analyst's responsibility is to verify what problems exist, how and where they originated, and how the conditions at hand can be corrected.

The composition of the study staff should be as follows:

1. A library officer possessing general-management responsibility and authority within the library's organization, to take supervision of the study and regularly report to the director and his executive group. Since interdepartmental problems are involved in a total systems study it is not advisable to assign the head of a functional department to this job since his functional interests may bias his interdepartmental views.\textsuperscript{25}

2. At least one member of the study staff fully trained and sufficiently experienced in the application of management-analysis techniques, preferably a librarian.

3. At least one member of the staff skilled in electronic data processing (EDP) methods, particularly if an automated system is contemplated; this member should also be a librarian.

4. Clerical assistance adequate to support the work of the study staff.

It is conceivable that the requirements in items 1-3 could be met by one person. However, it is more likely that two persons will be needed, even in a relatively small library, to furnish mutual stimulus, thus making "their efforts far more productive than one person working alone."\textsuperscript{26} This applies particularly in the design phase of a systems study to insure consideration of design alternates reducing the chances of a single solution with faulty characteristics.\textsuperscript{27}

\textbf{Defining the Study Problems}

The study staff is to develop, with the library's management, a detailed procedural plan and time schedule for the study, the first step of
which is the general definition of the problems to be studied and the identification and description of the specific problems involved. It is the responsibility of the library’s management to supply a clear and concise statement of these problems in the form of a written report or assignment prepared by management’s advisory committee alluded to above. Problem definition must be in sufficient detail to serve as a guide to the study staff members and to inform the other members of the library’s organization who are concerned with the activities named as areas to be covered by the study.

**LONG-TERM GOALS**

The next step, critical in planning and conducting this study, is the study staff becoming fully conversant with the library’s overall goals in relation to the problems to be studied. Goals are those factors that the management of the library determines to be important for accomplishment; the “planned projection” of the library’s aspirations. The statement of goals, the heart of the advisory committee’s written assignment, determines the major requirements resulting from demands that should be satisfied by the library through its data processing and informational systems. Goals then, are basic in evaluating the current system and in designing a new system. If the goals are not precisely and correctly defined and understood in detail, the results can only be an inaccurate evaluation of current operations and the design of a faulty system. For example, it is not enough to simply state that “improvements of service to users” is a goal. The written assignment should define each of the many factors suggested in this generalized statement of a major goal.

In any event the study staff should verify the validity of stated goals through discussions with library users, department heads in the library, department heads of the parent organization of the library, and with the key administrative officers of the library’s governing organization.

Long-term planning is implicit in defining the library’s goals. Because most libraries are in a period of dynamic and persistent growth, systems to satisfy long-term goals should be designed with the capability of handling increased demands. Thus computer-based systems are suggested. Such systems have the capability of less costly and more efficient growth as demands on the library grow. Today’s commonly applied manual systems often become more costly and less efficient under increasing demand and do not possess the “stand-by” qualities of the computer system in adjusting to growing requirements.
SCAPE

After the goals which indicate the purpose of the study have been defined, the scope of the study should be stated in written form and agreed upon by management and the study staff. Here the particular data processing systems within the library that are to be studied, as well as the organizational units in which the operations are performed and the activities involved, are identified in order to prevent wandering into other systems with which management is not concerned at this juncture. Within the system, priorities are established for the components thought to need early attention by the library's administration. It is important in specifying scope and priorities that the systems study staff not be too rigidly restricted, but rather be allowed a degree of flexibility permitting recognition of other areas that might be affected by the particular system directly assigned for study.

LIMITS AND RESTRICTIONS

Within the written scope of the study, management also should define any limits or constraints to be placed on the development of a system as well as the limits beyond which the study need not be carried to reach the desired solution of a problem. Examples of limits and restrictions are: (1) the type of system wanted—whether or not computer-based; (2) number and proportional distribution of personnel to be in the system; and (3) tolerable unit or total costs of operations of the system.

METHODS AND TECHNIQUES

In further preparation the study staff members should decide on the methods and techniques to be used in the study for obtaining and recording the necessary information. These should be determined in order to assure a logical, systematic study and to permit comparison of findings within the systems. For example, if statistical work sampling is to be used, the confidence level to be accepted must be agreed on in advance with applicable sampling techniques being uniformly employed; survey forms must be designed for each survey of requirements, current procedures, and inputs/outputs to be conducted; type and format of reports to be presented must be determined—that is, graphic reports such as organization charts, procedure flowcharts, PERT charts, graphs, tables, models, simulation, etc.; and written reports or other narrative materials must be agreed on.
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Also involved in the methods used are designation of the persons to be interviewed, the records to be obtained and analyzed, the equipment available and its use, and a detailed outline of the specific types of information to be sought. With respect to this latter specification, Optner supplies checklists which can be helpful. Adoption of uniform methods and procedures assures that the results reported by each study staff member are consistent in content and format and allow uniform comparison and evaluation by the staff in consultation.

WORK AND TIME SCHEDULE

As terminal planning steps the organization of the work of the study staff should be set down and a time schedule measured by man-days or man-months should be prepared for completion of its assignment. The types of skills needed for each assignment have to be determined—that is, managerial analysis, clerical, programming, and so forth. The responsibilities of each person in prosecuting and completing his study assignment should be explicitly defined based on a list of specific identifiable study stages, each with a target date for completion. Target dates for interim reporting to the library's management and to the study group as a whole should be set as well as the target date for submission of the final study report. The time schedule is not only important to the orderly and expeditious prosecution of the study, but also to administrative knowledge and acceptance of how long current library operations will be slowed or otherwise adversely affected by the study's demands on the operating time.

ANNOUNCEMENT OF STUDY PLAN

As the plan for the systems study is being formulated the director of the library should have introduced the idea to the library staff, indicating the reasons for the study and its objectives. Such an announcement would include: (1) an indication of the reasons for the study; (2) a description of its principal goals; (3) a description of the benefits expected; and (4) solicitation of the full cooperation of the members of the library staff, assuring them of their major roles and engendering their full support and interest in order that the study be successful.

When the planning is completed, the director should review the finished plan with the study staff and with other members of the library's administration. When he has approved the plan, the director of the library should make formal announcement of the undertaking of the systems study to the community served by the library, indicating the rea-
sons for the study and its objectives and anticipated benefits as well as explaining what problems the user of the library may temporarily encounter during the period of the study.

The library staff should be reassured at this time of the administration's awareness and sympathetic understanding of the disruption of each staff member's assigned duties and should be assured of the administration's firm support of the study. It should be demonstrated to the staff that without the cooperation and participation of each member, the study cannot lead to results beneficial to the staff and to the library.

STAFF TRAINING PROGRAM

Following the announcement of the starting date of the study, it would be well to conduct a short staff training program detailing the techniques used in a systems study. Discussion of these techniques should bring a better understanding of the study, generate the very necessary staff interest in it, and furnish knowledge of what information the analyst will be seeking in his contacts with individual staff members. The training program might well include description of the potential use and contribution of computers in library data processing operations and library services. At the same time the library staff should be provided with selected references to the current literature on library automation.

It cannot be overstressed that staff understanding, perceptiveness, support and participation down to the unit supervisory and key clerical levels are prerequisite to a systems study resulting in practicable systems design. Support in this phase of organizational improvement efforts will be carried over into the successful implementation of the study's recommendations and attainment of the operating objectives sought.

With the permission of the Association for Systems Management (formerly the Systems and Procedures Association), chapters 1 and 2 of J. W. Greenwood's *EDP: The Feasibility Study—Analysis and Improvement of Data Processing* have been used for basic guidance in preparing this paper which is an adaptive expansion of chapter 2 of Edward A. Chapman, *et al., Library Systems Analysis Guidelines*, New York, Wiley-Interscience, 1970.
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References

2. Ibid., pp. 23-24.
15. Webster, op. cit., p. 8; St. Thomas, op. cit., pp. 41-42; and Benjamin, op. cit., pp. 42-43.
21. Ibid., p. 21; and Ackoff, op. cit., p. 131.
EDWARD A. CHAPMAN

34. Optner, op. cit., pp. 88-93.

ADDITIONAL REFERENCES

These volumes are recommended as readily comprehensible texts for an introduction to systems analysis and planning techniques.

Systems Analysis as a Decision-Making Tool for the Library Manager

A. GRAHAM MACKENZIE

DEFINITIONS

"SYSTEMS ANALYSIS," in this context, is not the process which is the necessary prelude to library automation; it is something much more basic. It involves seeking out the fundamentals of a situation and applying rigorous scientific methods to their study, with the aim of finding an optimal solution to the problems facing the manager. It is, in all but name, indistinguishable from operations research (usually referred to as OR), which has been defined as "(1) the application of scientific method (2) by interdisciplinary teams (3) to problems involving the control of organized (man-machine) systems so as to provide solutions which best serve the purpose of the organization as a whole."¹

In this process it may be necessary to collect vast masses of data on the operations being considered, to establish unit costs or times, and to use the various other techniques of work-study; it will probably be necessary to devise some kind of model or simulation of various processes which are integral to the operation; but the one inescapable task in every OR study is to try to define, in quantifiable terms, the objectives of the organization as a whole. It may not be possible to light upon one final, all-embracing objective; but at the very least there must be intermediate objectives which, taken together, will meet a large part of this need.

Decisions may be short-term and tactical: If the book fund is increased by 20 percent, how many extra catalogers will be required to process the extra books? Or should catalog data be obtained from an external source? More important, however, are long-term or strategic decisions: What level of financial support should a university give to its

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library? What is the optimum collection size in a given situation? Traditional wisdom in this situation says "more means better;" but is this necessarily so if the library is seen as part of a larger corporate entity?

The library has advanced a long way from the time when it was merely a collection of books, with a relatively small number of users, each knowing his way about its shelves. With the expansion of higher education and advances in technology it has become much more a precision instrument for the transfer of information from the author to large numbers of users—often in a very short space of time, because of the numbers involved—who need a great deal of guidance and help. From a modest extension of the scholar's own personal collection of books it has become an essential segment of the educational process, as well as a tool of the advanced research worker.

The library manager is a relatively new concept. Traditionally the librarian has been a scholar who has acquired a veneer of professional skills to enable him to exercise bibliographical control over his collections, and a patina of the techniques of public relations and personnel management by which he related himself to his environment. In recent years, however, with the absolute growth of literature and increasing budgetary limitations, the emphasis has begun to change. The professional skills and techniques are still essential, but to them is being added a realization that a library, if it is to perform its full function, calls for the study of cost-effectiveness and similar concepts drawn from the world of industry. Without these concepts the manager only has experience, training and intuition to rely on, none of which is a satisfactory substitute for scientific method if limited resources are to be used to the best advantage.

**METHODS**

Their detractors have said that systems analysis and operations research are merely applied common sense. There is indeed a certain truth in this, but it is not the whole truth: the difference lies in the way in which the common sense is applied. The traditional OR study takes place in four discrete phases. The system under review is described (often by flow charting the processes which make it up), and particular attention is paid to delineating the key points in quantifiable terms. Once this has been done a series of mathematical models are built to define the various interrelationships within the system. The second stage is to measure the system as it is, by collecting objective data if possible, or otherwise by making assumptions (these must, however, be
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quite explicit). With the input of this information we then have a working model, and by varying one or more of the inputs or parameters the performance of the new system can be described. This information is presented to the manager, who can then make operational decisions between different possible courses of action in the light of his new knowledge of the probable consequences of each. The last stage of an OR study is the achievement of operational control of the system by providing the manager with the means of achieving his objectives over a period of time, and a system of feedback of information so that he can monitor system performance.

The essential differences between OR and common sense thus appear to be quantitative thinking, model-building, and the mathematical manipulation of data. Unfortunately, few librarians tend to think in a quantitative manner, and even fewer have the training to construct or work with models. It is worth noting, however, that the same is probably true of many captains of industry, although this has not prevented the widespread adoption of such techniques there, to the extent that many firms have their own teams of OR experts to advise top management. The same could well become true of libraries in the near future; indeed it is possible, as well as highly desirable, for librarians to become an integral part of an OR team.

OBJECTIVES

There is, however, one major difference between libraries and industry which makes the application of OR more difficult. In industry, broadly speaking, there is one overall objective—financial profit—and hence there is one single significant measure of the output of the system. This means that the conceptual analysis involved can be more directly and obviously aimed towards the end-product, which is clearly measurable. (This does not, of course, imply that an industrial systems study must aim at maximizing profit, but it does place the decision-makers in the position of being able to evaluate the results of different courses of action against the objective yardstick of the likely financial returns.) In a library, however, "profit" is a meaningless term. The profits of an industrial special library may perhaps be inferred or measured indirectly as a contribution to the overall production of the parent company, but this is a special case not applicable to public or academic libraries. In their situation even modern economic theory cannot make more than a guess at the benefits conferred on the community served.

APRIL, 1973
The central problem in any systems study of libraries therefore becomes not the techniques which should be used, but the precise specification of the objectives of the system. In this context it is useless to talk, for example, of serving “the reading, reference and research needs of its users,” or of “library services up-to-date and commensurate with their needs . . . founded on adequate collections,” as does the ACRL statement, if for no other reason than these concepts have no quantitative meaning. They may be taken into consideration at a later stage as qualitative factors which affect the subjective decision of the manager about the relative merits of different solutions to a problem, and indeed some arbitrary values may be applied to such considerations, if only to insure that they are not forgotten; they cannot, however, be specified as integral parts of the model.

Libraries may perform many different and often conflicting functions: some acquire and preserve books for posterity, others cater more to the immediate needs of their users—be these undergraduates, senior research workers or someone looking for recreational material to while away an idle hour. Some libraries provide an information service at a sophisticated level, others little or none; some are centers of scholarly research, others concentrate on curricular books; some have elaborate catalogs, others little more than finding lists; one may exist almost entirely for lending, while another keeps all its books within the building. With this diversity of purpose there can be no single, all-embracing objective, valid for all libraries. However, if we take as an example the academic library, and place it in its context as a means of making documents (books, journals, abstracts, nonbook materials, etc.) available to users, we can perhaps measure its effectiveness by the amount of success with which it does this.

A number of objective measures of library performance have been suggested, based more or less directly on this concept. The most popular has been the probability that a reader will find on the shelf the document he is seeking, although researchers have used different techniques for measuring and defining this probability. Buckland talks of satisfaction level and collection bias (the latter being a measure of the suitability of a library for browsing, as opposed to seeking a specific title), Urquhart of reader failure at the shelf, and Orr of a document delivery test which uses as its measure the delay in providing material. “Findability” alone, however, is not the whole story: postulate an (improbable) library which does not permit borrowing, and where readers are allowed into the stacks, but must leave the building again within
thirty minutes. Clearly the availability of its stock would be close to 100 percent, since the chance of any specific title being required by two people in the same thirty minutes is very small. In terms of people using documents, the library would be largely useless.

This consideration has led some investigators to consider as a measure of effectiveness the amount of time for which the reader uses a book: this is, after all, the end-product of the majority of library activities. Meier proposes "item use-days," thus equating ten loans for one day each with one loan for ten days. This is an improvement on the simple amassing of circulation statistics—although both methods are to some extent dependent on the loan period allowed—but says nothing about the quality or intensity of use. Hamburg chooses "document exposure"—the total length of eyeball-to-page contact per circulation. According to some tentative and unconfirmed findings quoted in Brophy, this time appears to be in a negative exponential relationship to the length of the loan period. This measure therefore seems to carry more conviction than the others in an academic library situation, since a very short loan period—which is, subjectively, less valuable to the reader than one of medium length—will carry a lower weighting. Conversely a very long loan period, when a high proportion of the books on loan will be lying unused on the borrower's desk at any given time, weighs only little more than the loan period of medium length.

It may not be necessary for some purposes to define a single all-embracing objective for a library: certain aspects may be divorced from the main concept of book use and be treated in isolation. It is perhaps in this area that most systems work has so far been done, simply because it is easier to identify and analyze smaller problems. The economies of storage in stacks have been studied by the Purdue team under Leimkuhler and, as book retirement, by Morse and Raffel and Shishko. Burkhalter has produced a series of case studies on, for example, exit control and charge-out and accounting systems, although some of these are nearer to conventional work-study than to systems analysis. The Lancaster team has produced models of book processing and in-house binding. There is, however, a grave danger of suboptimization in looking at only one aspect of a library in isolation. Efficiency may well be the enemy of effectiveness, as in the case of a circulation system designed for economy of operation which actually reduces the availability of books to readers, and therefore the amount of use that can be made of the library.
MODEL BUILDING

“The basis of all scientific work is experimentation. Experimentation is just what apparently cannot be done with administrative systems. . . . OR does not experiment with the system itself, it experiments with a model of the system.”

Whenever human beings are concerned, the only certain thing is that nothing is certain; therefore we cannot say that a library and its users will, on any given occasion, interact in one specific way. However, if a large number of observations are made and analyzed, we can say a great deal about the probability that a particular event will occur; it is on this basis that library models are constructed. Of course the predictions they generate will often be in error about individual readers or books; but in the aggregate they will be more right than wrong, and thus the library manager will be able to base his actions on statistical predictions rather than guesses.

This is not the place to examine in detail the technical aspects of model building; many varieties are possible, ranging from a simple description of the probability of some event occurring to a string of equations representing a series of complex interactions between the library and its users. It must, however, be emphasized that the essential character of any model is that it should represent all those parts of the real life situation which may significantly affect the outcome. If the analyst has been able to identify and describe each part of the system in a logical way, he may be able to eliminate some of them from the model by sensitivity analysis; e.g., in studying book availability in an academic library it may be found that in-library use (which poses difficulties for the data collector) can be ignored, since neither a very large nor a very small value for this will make a significant difference to the results which the model produces. Similarly, if data cannot be found for some part of the model (for example the effect on demand of differences in the pattern of teaching in various disciplines), it may be possible to treat this effect as a “black box,” and earmark it for future study. In the meantime, the investigator can input a range of values and make a subjective judgment on the most likely ones.

DATA COLLECTION

Most libraries produce statistics annually; in many cases, however, these are merely the conventional figures of books acquired and cataloged, numbers of loans (perhaps analyzed by status of borrower or by
subject), and overall figures of expenditure. This kind of gross material is not what is required to quantify a model; needed instead is information on what the individual user does when he enters the building or borrows a book, on the number of times an individual title is requested by borrowers (or needed by borrowers—this is not the same thing), and similar detailed facts which are not normally recorded during the routine processes of most libraries.

This information must then be the object of special data-collection exercises. These may be direct, e.g., the analysis of issue records over a period to find out the distribution of borrowing among various categories of readers, the examination of date labels to discover the distribution of use among different categories of books or individual titles, or visual observation of readers' behavior to see how much the catalog is used. Or they may be indirect; the usual technique here is the questionnaire addressed to a sample of readers, although blanket coverage has on occasion been attempted. Both methods have their advantages and disadvantages: direct observation is more accurate and objective, but can be very tedious and time-consuming; the indirect method has all the normal pitfalls of survey techniques (the danger of loaded questions, the difficulty of insuring that the sample is representative, the risk of influencing behavior by the mere fact of asking questions about it). Also the indirect method is the only way of getting certain types of information, and is usually cheaper than direct observation because a well-chosen sample can often give as much information as complete coverage, with as much accuracy as the model needs.

It is worth noting that automation is often heralded as the answer to the data-collection problem. It can indeed provide more information more easily than can manual methods, but only if the designers of the system have foreseen from the start what will be needed for statistical and control purposes. This does not seem to be the case in most of the systems presently in use in libraries.15

Data on system performance and requirements are perhaps the most difficult to collect; but equally important is information on costs. It is comparatively easy, by applying standard work-study techniques to library operations, to establish the direct unit cost of any given operation—acquisition, cataloging, circulation. It is more complicated, but possible, to establish the total direct and indirect cost of, for example, the loan of a single book, made up of a proportion (because the book will probably be lent more than once) of the purchase price and processing, storage and circulation costs. This is only one side of the equation;
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for every cost there ought to be a corresponding benefit. If a single circulation of an average title costs $3.50 in total, then either the benefit to the institution is greater than this, or the library is misusing money which could be spent more effectively on something else within the institution. One cannot measure benefits directly; Raffel and Shishko\textsuperscript{11} at M.I.T. and Hawgood\textsuperscript{18} and his team at Durham have used sophisticated PPBS and regression analysis techniques respectively, based to a large extent on the values which can be imputed to a library by its users. This approach, however, seems to be surrounded by dangers. Although it measures a consensus of opinion, it is nevertheless still subjective and can at times degenerate into a circular argument. One feels that there is a need for a quite different method of analysis, as yet undiscovered.

USE OF THE MODEL

Once the model has been constructed and tested, and quantities have been attached to its terms, it is ready for use. The objective of the manager is usually to optimize one specific aspect of his library; models have not yet been developed, and may never be, which are capable of describing all the complex interrelationships which constitute the library and its environment. He therefore has before him a choice of possible actions, some of which may have been suggested by the model itself. His need is first of all to discover what are the likely results of each, in terms of performance and cost, by simulating the performance of the system. Once this has been done he may have to assess the political implications of the (theoretically) optimum solution. If, for example, this can only be obtained at the cost of reducing the privileges traditionally accorded to faculty borrowers (who are often, indirectly, the policy-makers for the library through their participation in committees), this may be considered inexpedient or even impossible. Such intangibles are difficult to program into a model, and yet they are a real factor in decision-making; the model can therefore only be an aid, and qualitative judgment still has a major part to play. Perhaps it is at this stage, rather than at the earlier one of quantifying the model, that the assessment of benefits can best be taken into account, albeit in a less formal manner.

SYSTEMS AT WORK

The last few years have seen an enormous growth in the amount of effort directed towards systems analysis in libraries; but to see one of the

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most elegant and far-reaching applications (simple though it is by comparison with much of today's work) one must go back to 1959, when plans were being made in Britain to improve the performance of the national interlending service for scientific journals. At that time there were, broadly speaking, four channels through which a library might borrow a title it did not possess: through one of the ten Regional Library Systems which cooperatively maintained union catalogs of the holdings of libraries in their respective regions; through the National Central Library in London, which held very little material itself, but had an incomplete national union catalog; by direct, semiformal, request to another library known to hold the required title; or by application to the Science Museum Library, which was in effect a national lending library for this type of material. The first two channels were relatively little used because of their slowness and uncertainty. The Science Museum Library, although the most important single source of loans, was becoming less and less effective as demands on it grew, since its lending role was only secondary.

The Department of Scientific and Industrial Research was given the task of providing a comprehensive and efficient service, and, to the disgust of the library profession, a comparative unknown—D. J. Urquhart—with no professional library qualifications was put in charge of what was then known as the Lending Library Unit. Urquhart, luckily for the future of the National Lending Library for Science and Technology, was uninhibited by traditional professional expertise. He was a scientist, and applied the techniques which have since become known as systems analysis. He stated objective was to insure that there were, somewhere in the country, sufficient copies of frequently used periodicals to meet the total interlibrary loan demand, and at least one copy of infrequently used titles. By analysis of loan records in the Science Museum Library he demonstrated that the demand for its titles was a rough measure of the demand nationally, and that Bradford's Law of Scattering still held. He then used the Poisson distribution to predict the rate of arrival of demands, and his model showed that a single complete collection, with multiple copies is required, would perform much more efficiently and cheaply than the alternative of a decentralized collection spread over ten or more self-sufficient regions. The history of the National Lending Library has justified at least the general tenor of his calculations; at a more personal level Urquhart himself has succeeded in overcoming the hostility and suspicions of his more conven-
tional colleagues to the extent that in 1972 he was elected president of the Library Association.

The second example of a model at work is the variable loan and duplication policy developed at the University of Lancaster, and reported by Buckland. In the course of a research project it was discovered that a previous attempt to provide an efficient circulation system by using a long loan period in conjunction with an efficient recall procedure had in fact resulted in suboptimization, since the probability of a reader finding a specific book (satisfaction level) was only about 0.6. This was considered too low, and the research team was given the objective of raising the probability to 0.8. A model was constructed using a Monte Carlo simulation rather than the queuing theory favored by Morse, and a number of alternative courses of action were proposed, consisting of duplication or one of several different sets of loan policies. The tangible and intangible benefits and costs were compared, and the solution chosen was a combination of duplication and a loan period of seven days for the most popular 10 percent of the books. The result of implementation was that satisfaction level rose by the desired amount; however, demands on the service also rose, and, in the three years since 1969, the satisfaction level appears to have gradually reverted to approximately its original figure of 60 percent. The overall performance of the system has nevertheless improved considerably, although in an unforeseen way: since demand has risen (probably because of users' reaction to the temporary improvement in satisfaction level) and has stayed high, book use, whether measured in terms of issues per head, or of document exposure, is about half as high again as it was prior to implementation. Further models are being developed to investigate the new situation, and more attention is being paid to the interaction between the system and the user than previously, when the library was thought of more as a physical than a biological system, and the user was considered as a "black box."

It is somewhat surprising to realize that, in spite of the activity on both sides of the Atlantic in recent years, very little appears to have been done in practical terms. M.I.T., the University of Michigan and Purdue University all have extensive graduate programs in OR oriented towards library service, and substantial numbers of papers and books have been published, notably those of Morse, Raffel and Shishko, and Burkhalter (although perhaps the latter leans toward work-study). In Great Britain there have been major studies at Durham.
Systems Analysis as a Decision-Making Tool

Lancaster\textsuperscript{13} and Cambridge,\textsuperscript{18} all with the avowed intention of examining library systems, and all with support from the Office for Scientific and Technical Information. From the published literature it appears, however, that only at Lancaster and Michigan have there been any major changes in an operational library system as a result of OR studies. (This may be an unjust comment; Newhouse and Alexander\textsuperscript{19} imply, although they do not specifically describe, changes in the Beverly Hills Public Libraries, and Houghton\textsuperscript{20} describes a new policy for special library journal subscriptions which may have been put into practice. However, if librarians are actually basing operating decisions on such techniques, their light appears to be small and their bushel exceedingly large: one would expect full and explicit publication of a technique as new as OR.)

It may be that at this stage there is more need for enabling and theoretical studies than for practical operations research in libraries. It is more likely, however, that the profession as a whole is either not convinced, or ignorant, of the potential value of these attitudes. There is a need for librarians to be more intimately concerned with the day-to-day realities of OR as members of the team. If OR is left to its own professional exponents there is a risk that elegant theoretical model building will gain preference over more rough-and-ready, but more practical, techniques which can benefit libraries. There is also a need for library schools to teach management in a more quantitative way; it is true that the average student may not have much opportunity to put these theories into practice during the early part of his career, but effective management depends on attitude as well as on techniques, and if the student can be brought to appreciate this at an early stage in his career, he will be more receptive when he is later placed in a position where such skills can be of value to him.

References


Opinions on the scope of systems analysis vary from the very narrow one of covering only the present system through a much wider definition which includes design of a new system through the monitoring of its implementation. As a prelude to library automation it seems appropriate that systems analysis be considered as potentially including the design of a new system—if indeed the investigation and evaluation of the old system result in a recommendation to do so.

Chapman and St. Pierre defined system analysis as “the systematic and logical analysis of a problem and the design of a system to correct any of the inefficiencies or errors which exist in the current operations.”¹ They divided systems analysis into five steps: understanding current procedures, delineating requirements, determining the system’s inputs, evaluation of procedures currently used with respect to their fulfilling requirements, and finally, either design of a new system, proposal of modification of the existing system, or recommendation to accept the current system if it was evaluated as successfully meeting requirements.²

Systems analysis per se does not depend on the use of a computer. Robinson contended that only systems design, not systems analysis, can be discussed with a particular field in mind.³ However, as Becker pointed out in an early paper, if a library undergoing systems analysis has access to computers, the analyst will routinely consider their application.⁴ Adelson explained the interrelationship of the systems approach and the computer as stemming from the fact that usually the systems approach is applied to large problems and these are tied to


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computers because of the large amounts of information which are gathered, organized, and utilized.\textsuperscript{5}

The scope of this article is restricted to applications of systems analysis to technical processing functions in libraries. George Hodowanec, in teaching technical processes at Drexel University, includes within the scope of technical processes those procedures within the circulation department such as charging systems, activities of the acquisition department and the serials department, the operations of the cataloging department and additional functions such as binding, mending, and repairing tasks.\textsuperscript{6} Technical processing, therefore, can be thought of as including traditional housekeeping activities and would include, circulation, reserves, ordering, processing, production of catalog cards, periodicals, serials, and binding. Such functions are good candidates for library automation. As Weaner points out the technical processes lend themselves to automation because they either involve repetitive tasks or are jobs which are deterministic and highly structured, with decisions, if any, that are repetitive and of a low order.\textsuperscript{7}

In reviewing the literature relating to systems analysis preceding automation of technical processes as defined above, publications appear to be divided into two large segments: (1) those general in nature, i.e., not specifically related to the application of the technique at any individual institution or group of institutions; and (2) those articles which refer specifically to actual experiences in the use of systems analysis when automating one or more technical processing functions. While this division will be followed in this article, it should be realized that not all relevant papers are cited, due in part to the large number of publications which have some bearing on the topic. However, an attempt has been made to include papers which are representative and significant, while some are included because they emphasize points not made elsewhere.

Most authors divide systems analysis into several distinct phases which may, however, overlap in actual execution. Following are summaries of these phases as presented in several publications. Part of the differences encountered in the phases outlined from author to author depend upon each individual's definition of the scope of systems analysis.

**General Literature**

Heiliger and Henderson see systems analysis efforts being directed
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to the selection of the best approach to reaching a given goal. They suggest the following five steps in the analysis phase.

1. Establishment of criteria recognizing requirements, restrictions, and objectives. There will be tangible criteria, possibly focusing on cost, as well as intangible criteria including values to be retained, factors of risk and delay, and the pace of progress which patrons and staff can sustain and accept.

2. Quantification of the system—identification of restrictions and demands outside the system. It is important to establish all interfaces with activities or organizations not within the system. At this point the authors consider it critical to make a distinction between physical objects and logical data.

3. Formulation of alternatives which can be aided by the use of models. They may be abstract, such as a flow diagram, or more tangible, as in the form of an operative diagram or simulation of a possible solution.

4. Selection of the alternative to be pursued, based upon the application of the evaluation criteria to the feasible alternatives. This should be based on consideration of both economics and practicality. The strengths and weaknesses of both humans and computers should also be considered.

5. Exposition of the specifications of the system. It is vital that all purposes are understood, that a sound approach is being used, and that targets are clear.

Gechman, writing to heads of libraries with decision-making responsibilities in library automation projects, identified eleven steps followed at Information General, Inc., as leading to the implementation of an automated system. The first three steps fall within the scope of systems analysis. The first is establishing the goals and objectives of the system. Gechman identifies this as "the most important function of the whole effort." The foundation of the system must be strong and requirements must be established clearly if the system is to meet the needs of its users. The second is systems analysis itself, in which the overall problem is defined within the context of a computer-aided environment. Here the most critical tasks are the determination and approval of descriptions of input and output data. After requirements and objectives are both known, specifications for a new system are prepared, along with descriptions of any present manual system. The third step, the specification manual, should cover requirements of the proposed new system and should be given to library management for approval.
Only after approval is granted at this point would work proceed on the other eight steps which cover design of the system in detail sufficient to permit programming and implementation.

A 1971 publication by the SPIRES/BALLOTS staff at Stanford University, “System Scope for Library Automation and Generalized Information Storage and Retrieval at Stanford University,” presents a discussion and sequential presentation of how it sees the five major tasks in what it terms the preliminary phase of system development. The sequence of steps identified begins with determining the organization’s general operating requirements, in terms of objectives, products and services. It is followed by the study and documentation of present operations. After the requirements are defined and the current system analyzed, a statement of limitations or inadequacies is delineated with the purpose of discovering those areas which could profit from manual improvement and/or computer support. Once the limitations are known, a long-range scope for the system should be established which clarifies areas in need of system development or research. Then, having outlined the whole system, the Stanford group recommends that a first area to be implemented be selected which provides “an optimal integration of computer and manual resources so that the areas in most need of computer help are aided and means for further research are provided.”

While not including systems analysis in those words, Bellomy in 1969 outlined a series of steps to be followed in development of a library system. He suggested: (1) formulation of module objectives, (2) documentation of existing operations including specific items and specific data elements, (3) analysis and summarization which should culminate with an informal summary of a module parameter, and (4) formulation of design concepts, a task which includes the identification of the widest conceivable range of alternatives. Step five is the preparation of detailed design specifications allowing for hardware constraints.

In another paper, Bellomy and Jaccarino indicate that one of the most critical elements of the analysis preceding library automation is thorough consideration of all possible requirements which might be placed on the system. This is reinforced by Markuson, who adds another dimension by stating that prior to library automation a great deal must be known about the local setting. The most important elements therein are the library network, the parent institution, the user group, and the history of the library itself. Systems analysis would show that in some cases past decisions can influence future actions, in economic
factor limitations if nothing else. For instance, she points out that the decision to set up new files cannot be taken lightly as data will be accessed for many years. Furthermore, in many library environments it is difficult to get accurate cost figures. Due to many exceptions encountered in library processing, only average figures are readily available for use.

In a 1967 article, Covill discussed phases through which a library automation project passes. Although he has a narrow definition of systems analysis, the first four phases he described fit within the framework of systems analysis as a prelude to library automation. The first phase, analysis and documentation of the present operating system, is considered by Covill to end with a problem statement covering the reasons the present system is inadequate and the course of action to be pursued to develop a solution. The problem statement would be accompanied by a picture of the library processes as existing at the time, expressed in words, diagrams, and charts. The next step would be establishment of the new system to be designed, followed by its design—the plan for which should be furnished, along with all files, reports and records generated, to the librarian for review. Covill lists as step four the making of decisions on equipment and storage to be used.

In discussing the work which must be done prior to programming an automation project, Kimber lists the following steps, not necessarily in sequence: gaining a clear understanding of the work to be done, knowledge of the available data, and desired results. He would reduce the requirements to a set of flow charts and written specifications for the purpose of clarifying the analyst's concepts, exposing omissions, and removing ambiguities. He rightly emphasizes that the whole task of job definition be thoroughly carried out in order that computer time, plus a great deal of effort, not be wasted later in making revisions in the system.

A paper presenting the sequence of steps in systems analysis with particular relationship to library automation is Pratt's contribution, "Systems: Components, Characteristics and Analysis." He states that understanding the present system is basic to designing and implementing any improved system, but particularly a mechanized one. Each decision, no matter how small, that is made in the normal course of duties must be known, and must be studied to be explicitly clarified. Pratt indicates that the sequence of steps proceeds to determination of the objectives of the present system. Then he specified the next step as one which many authors do not include under the heading of systems anal-
ysis—the determination of present costs. He indicates that knowing present costs is essential because decisions in selecting a new system will have to consider comparative costs. When considering the new system he recommends describing the environment in which it will operate, and determining its objectives. There will be alternative possible systems and they must be compared for the best possible overall selection. When an optimum design is reached it should be costed accurately and the system described in detail. To complete the task of systems analysis, a systematic plan for implementation of the new system should be developed, and, as part of the design of the system, there should be preparation of adequate documentation.

While not specifically presenting a series of procedures to be followed in systems analysis, Auld related some qualities it must have in order to prevent failure in library automation. He stressed the importance of good communication as part of good systems analysis. However, he pointed out that good systems analysis also requires an understanding by the analyst of the totality of that with which he is working, as well as establishing correctly the relationship of each part to all other parts. Another view of what is needed to have a successful library automation program was presented by Waite. He believes that successful completion of the preliminary phases requires close communication among all participants including executive management, project management, operating librarians and systems engineers.

Cox, writing in terms of system design which occurs prior to automation in a university library, indicated four factors involved: analysis of the existing activity, establishment of the principles on which the system will be based, costing and functional evaluation of the proposed system, and finally, design of the system.

As can be deduced from the preceding discussion, there have been numerous publications dealing with the sequence of steps to be followed in performing systems analysis prior to automation within libraries. The different authors emphasize different aspects, but in general they present the need for an orderly, logical investigation of current operating systems with a clear presentation of positive and negative features of the alternative solutions. Harrison Bryan, an Australian who spent a good deal of time in the United States looking at examples of library automation, concluded that most failures and difficulties of library automation resulted from overly hasty planning and/or a lack of firm commitment to hardware. To help insure success of an automation project, he recommends that the planning (analysis phase) be
allowed twice the time originally scheduled because the preliminary planning is the most important aspect in the introduction of automation.

**METHODS, TOOLS, TECHNIQUES**

In addition to outlining a logical series of steps to be followed in systems analysis, many of the automation papers, especially those published in the 1960s, presented a discussion of methods to be followed along with various tools and techniques to be utilized. In general the techniques of systems analysis are equally applicable whether or not automation is a probable step. One of the most widely used techniques is flow charting. Flow charting can be used at least two ways within the context of systems analysis. The first is to set down each step followed in the existing manual system. A second means of utilizing flow charting is in designing new systems where proposed steps to be followed would be identified. Hammer mentions flow charts in the latter category where they “describe the hundreds or thousands of interrelated steps needed for the computer to accomplish the desired result.”

Szeplaki presents lengthy instructions on how to prepare flow charts of existing library operations. In that situation a flow chart may be one of two types: step-by-step work flow chart or a document-by-document work flow chart. To accomplish a work flow chart Szeplaki recommends beginning by securing a job description from each individual staff member whose area is under study. Then, using the job descriptions as a base, draw preliminary flow charts. Next, interview each individual, without necessarily filling out a complicated interview form. Szeplaki does not give details on preparing a step-by-step flow chart, but he elaborates on preparing a document-by-document flow chart. He considers document-by-document charting to have several advantages over step-by-step, and should be consulted by individuals making decisions relating to the depth and type of flow charting to be pursued in the systems analysis of any probable library automation project.

Interviewing is listed by Robinson as one of the most obvious techniques of systems analysis. Other techniques are less well known such as the construction of decision tables.

The early 1970s have witnessed a very significant development in the general field of library automation which includes ramifications for systems analysis. This is the publication of several major, comprehensive guides to library automation or, in any case, to library systems analysis. Thus, in contrast to the early years of library automation, in which in-
dividual papers would discuss steps or methods to be employed in systems analysis prior to automating, or perhaps staff implications involved, there are now available some important works which synthesize and consolidate knowledge regarding many aspects of data processing in libraries. While many of these aspects change rapidly, the techniques of systems analysis tend to have enduring applicability. In this regard, the sources discussed below should have value for a considerable length of time.

An absolutely invaluable source for anyone engaged in conducting systems analysis as a prelude to automation of technical processing functions is the 1972 publication by Markuson, et al.\textsuperscript{27} It is extremely useful for its guidelines for decision-making in the early feasibility study stage, equipment and costing aspects, the steps and techniques of systems analysis, and for comparative information on automated projects as well as lists of most of the likely alternatives in automation of the various functions—whether acquisitions, cataloging, circulation, serials or other.

The steps for systems analysis presented by Markuson will not be reiterated in detail here. It is, however, worthwhile to mention a few points not emphasized so clearly in previously referred to papers. First, file analysis is a major part of analysis of the present operation and, secondly, conditions which might be imposed by outside environments such as agency, library community or other should be investigated.\textsuperscript{28} This guidebook also includes a very comprehensive list of analytical techniques. These are discussed and explained in some detail with specific references to the advantages of each. As an example, decision tables which utilize “yes” and “no” information are singled out as valuable because they come close to simulating the logic used in computer programming.\textsuperscript{29} Good guidelines are also included for systems cost analysis.

Another major publication covering an even wider scope is the 1970 tome by Hayes and Becker, \textit{Handbook of Data Processing for Libraries}.\textsuperscript{30} The information on the actual steps and techniques of systems analysis is very limited compared to Markuson. However, the Hayes and Becker effort is definitely a basic reference tool for library systems analysis. It is especially valuable, in the context of this article, for the descriptions of typical systems in the technical processing areas—including the data involved, the types of reports produced, and options of features which could be incorporated into these applications.

Not as encompassing in scope as the two efforts discussed above, but
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nevertheless invaluable to those individuals involved with systems analysis and design of automated library functions that involve conventional data processing, is Library Systems Analysis Guidelines by Chapman, et al.51 The nucleus of the information has appeared in several previous publications by one or more of the authors, but here it is brought together, updated and expanded. They emphasize that a systems study is an essential prerequisite to the design of a successful automated system. However, an automated system is not necessarily the result of such a study. It includes a look at the phases of analysis, detail on methods and techniques of analysis including job descriptions, worksheets for the survey of inputs, flow charts and others. Their section on preparing a report of findings should be useful to many. Included is a section on systems design with special considerations for design of a computer-based system.

PERSONNEL

A final area touched upon in many general papers pertinent to the topic of this section is personnel. Who should be the person(s) responsible for performing systems analysis in a library when a probable result is automation of one or more technical processing functions? Probably, the most frequent answer is that the analyst, or at least the project director, will be someone who is also a librarian with some training in programming. Some authors who recommend a combined librarian/analyst are Veaner,52 Szeplaki53 and Lebowitz.54 On the other hand, Hammer believes that a professional analyst is a requirement.55 De Gennaro, writing at a time when trained and experienced library systems people were in short supply, did not care whether the person doing library automation was primarily a librarian in background or primarily a computer expert as long as he was dedicated to the purpose of library automation and took steps to acquire expertise in the areas he lacked.56 Frequently the use of outside consultants is recommended for the systems development stages. Nevertheless, some in-house capability is required for maintenance.

Based on personal experience, it seems probable that librarianship is attracting, and will probably continue to attract, individuals with strong data processing backgrounds. These individuals, comfortable in both worlds, should be in a position to bring the two together harmoniously.

There have been many case histories of operational automated projects published as well as descriptive papers of planned or imple
mented systems. Frequently they include comments on the methods or techniques of systems analysis followed. Following are representative references to some of the most informative or useful papers of this type.

**Specific Project Literature**

In the early days of library automation, there was often little formalized analysis. Many librarians were unaware of the desirability of careful planning and of sticking to projected schedules. Furthermore, in the early and middle 1960s not many librarians had had experience or training in systems analysis and design, or in programming. Dobb presents a useful, candid account of some early informal processes at Simon Fraser University in Burnaby, British Columbia, out of which evolved more systematic approaches including the recognition that there should be staff exclusively assigned to systems analysis and design.97

Probably in the early 1960s many automated projects just evolved without any formal planning. Frequently these projects got off the ground because of the enthusiasm of one individual in a given institution. At the National Center for Atmospheric Research Library, after an initial decision that automation could work, the next decision was to produce an announcement bulletin that was currently prepared manually. After several experimental attempts a satisfactory product was achieved. McCormick explained that their approach to automation had been to begin with an analysis of a desired product and to work backwards to determine the input requirements, which were then coordinated with other sections of the system.88

Thus, when both computers and library automation were in relative infancy, it can be seen that actions were frequently taken on a trial-and-error basis. As experience in the field began to demonstrate that increased positive results could be achieved with an initial systems analysis approach, and as more librarians achieved formal computer experience and/or training, the trial-and-error methods gave way, in most instances, to more systematic endeavors. Some specific examples of actual experiences in systems analysis which led to applications of automation to technical processes are presented below. It is intended as representative but not inclusive of the total publications pertinent to this topic.

Several authors are on record as beginning the analysis process with a feasibility study. These include Cage, whose feasibility study had the purpose of determining if it was practical to use the computer to pro-
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vide assistance to the acquisition department. Crismond reported preliminary planning that was initiated with a survey to determine the needs of the San Francisco Public Library, and testing of the feasibility of new serials procedures. Later, detailed planning at the San Francisco Public Library included determination of size and format of the catalog, the number of listings it would contain, the input forms required and data elements to be included on forms.

Lebowitz related the list of steps followed in the automation of serials at the Atomic Energy Commission. These included, as a first step, a study of the proposed mechanization in relation to the library as a whole. A feasibility study was conducted, followed by consideration of the proposed output and the available hardware.

Another early experience was in the acquisitions area at the University of Michigan. It was initiated with a study to determine the feasibility of using a computer system in the book ordering process. Thomson and Muller described the series of steps they followed once the feasibility of such a system was considered favorably. The steps in sequence include: determination of what the system must accomplish; definition of the types of information contained in the system along with clarifying the necessary reports; definition of files; review of the proposed approach by a programmer; submission of the proposal to the director of libraries; and finally, after the approval of the proposal, design of the system in detail. Dunlap also commented on the University of Michigan's early experiences in automation of a technical processing function. She indicated that once the preliminary proposal was drafted, cost and feasibility studies were made. A major factor in deciding favorably for automation of acquisitions was that while initial costs would be high, there would be long-range savings.

An interesting discussion of a feasibility workshop is presented by Epstein, et al. It involved five colleges and universities in the San Francisco Bay area and was conducted by Stanford University for the purpose of exploring the feasibility of a regional library automation network based on Stanford's BALLOTS program and its support of technical processing. This study team produced a report which provided cost and benefit information, furnished to the director of each library, as a basis for decision-making.

The BALLOTS project at Stanford is well covered in the literature, including in The LARC Reports. That report encompasses an extensive discussion of the history of the systems analysis and design phases. It began with such functions as the study of existing files, input and
output documents, and data elements. In the detailed analysis phase, requirements of the system were delineated in minute detail. Discussion of other stages of analysis and design are also included, making the Stanford experience a significant account of an actual experience in systems analysis preceding automation of technical processing functions.

Many authors mention the attention they paid to existing systems at other institutions. This can be done either by personal visits to the institutions, by a literature review, or both. Among the authors who discuss the value of comparison are Cowburn, Wilkinson, Miller and Hodges, and Byrn. The latter paper is particularly noteworthy because it provides a comparison between the middle 1960s and the early 1970s as to the relative abundance of literature detailing the experiences of various libraries in automation projects. Byrn indicated that the University of Oklahoma staff was so disappointed in the paucity of available literature of a nontheoretical nature, they initiated a questionnaire to survey 194 university libraries to determine which institutions had planned or implemented automated systems in their libraries.

It is clearly seen that in the last decade library automation has made great advances. More institutions have some and much more has been published, both by members of individual institutions and in large scale works covering the general state of the art. A valuable survey by the Information Science and Automation Division of the American Library Association, the American Society for Information Science, and the Special Libraries Association is currently underway. Its purpose is to compile data on all existing library automation programs and it will provide great detail concerning available sources of software.

At Eastern Illinois University the need for revising the circulation system led to informal discussions of alternatives by the librarians. The ensuing review resulted in a task force composed of representatives from the library, the data processing center and the administration. When the group recommended a computerized on-line circulation system as one possible solution, the administration authorized detailed analysis and the preparation of a design proposal. Rao and Szerenyi outlined the main considerations in the design of the BLOC (Booth Library On-line Circulation) system and emphasized that its aim was "a system that would provide the best possible service at the least cost in the long run."

Several publications by Kilgour discuss the systems analysis and
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design involved in the development of automation of the Ohio College Library Center (OCLC). Among the techniques of analysis used at OCLC was simulation. It was instrumental in the selection of hardware to be used, and in revealing that there was inadequate prior knowledge concerning the operation and efficient organization of a huge file in an on-line situation.

Additional examples of the use of the technique of systems analysis prior to implementing an automation program are, of course, covered in the literature. Many of these are "buried" in papers whose primary purpose is description of a particular system. Some of these will be mentioned in other papers in this issue of Library Trends. Several sources for locating additional literature exist, among which the Annual Review of Information Science and Technology, published by the American Society for Information Science, is particularly notable.

Along with attempting to review each year's literature, the Annual Review generally includes some synthesis of the various fields covered, including library automation. Some of the authors specifically discuss systems analysis and the latest trends in that area. Griffin, writing in 1968, covered the topic and emphasized systems planning and its necessity. Two years later, Parker, in reviewing the literature for 1969, commented on the abundance of articles dealing with the technique of systems analysis prior to planning for library automation. At that time he noted the repetitious nature of many of these publications and cast doubt on the justification of their continued publication.

In 1972, Martin, in the seventh Annual Review, noted that the literature clearly reflects changes which have taken place in library systems analysis. Recent publications tend to emphasize cost analysis, and the evaluation of variables which are difficult to quantify. In addition, she sees that the growth and development of networks is probably a reflection of a maturing field.

In general, maturation of library automation and the systems analysis which precedes its implementation is observed by this author. Some indicators of the increasing sophistication of the field are the publication of the guidebooks discussed previously, particularly Markuson et al., Hayes and Becker, and Chapman, et al. These works are all the result of considerable experience in the field and for the most part are syntheses of existing bodies of knowledge rather than containing work original in these particular publications. Further, in the early 1960s there were a virtual handful of library automation papers produced.
RUTH C. CARTER

Each year, the literature has expanded dramatically both in general papers and in published results or progress reports of specific efforts.

Another change noted from both the literature and from the author's personal experience relates to the availability of trained and experienced personnel. At first, systems analysis was often only haphazardly employed when an automated project was considered. Frequently, it had the form of informal discussions between a librarian with no computer experience and computer center staff with no library experience. Gradually, through trail and error for the most part, a small cadre of individuals experienced in library systems analysis and automation developed. In recent years, the library schools have been able to provide considerable training for their graduates in automation principles and the techniques of systems analysis. In addition, as indicated previously, many individuals with prior experience in systems analysis and/or programming have been attracted to the library profession and have attained education and experience in both areas. At present, there does not seem to be any serious shortage of individuals with experience or expertise in library systems analysis.

This increased availability of trained and experienced personnel should be reflected in a professional, thorough conduction of systems analysis and design in most instances. Many applications are now carried out in a routine manner, especially in smaller institutions. Furthermore, most staff members of libraries are now prepared to accept systems analysis and some computer applications as routine. They too have come to understand the process better and not to expect instant miracles. It is better understood that systems analysis is an iterative process where continuing feedback results in continuous analysis and redesign where appropriate.

Now that automation projects are successfully operational in many libraries, it is possible to do serious planning for joint ventures in which many institutions are involved. The rise of library networks, most with implemented or planned automation projects, is a definite sign of the increasing maturity of the field. Based on the confidence achieved with success in local situations, the phenomena of networks engaging in library automation should continue for some time to come.

Finally, in an overall appraisal of the utilization of systems analysis preceding library automation, it seems a fair conclusion that systems analysis is becoming routine in libraries, particularly in instances where automation is seriously considered or thought probable. Even when the
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use of the computer is not preconceived as a likely result, machine alternatives are routinely considered. As Cox states, automation in libraries is virtually inevitable due to increased demands for service.55 Other factors including the large volume of materials handled and available technological aid in the form of computers are also contributing to the rapidly increasing number of applications of automation in library technical processes. In any case, systems analysis, as a prelude to library automation, is an inevitable commonplace fact of life in libraries.

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Analysis and Evaluation of Current Library Procedures

FRED J. HEINRITZ

Charting a new course implies a knowledge of one's present position. Thus, analysis of present procedures is the logical prelude to design of a new system. Analysis consists essentially of detailed description by means of special techniques such as charting and sampling. Evaluation is a special aspect of analysis and dependent upon it. It implies comparison and tells us where we stand with regard to a formal standard, in relation to others, or in relation to ourselves at some other point in time. It thus stands between pure analysis and systems design.

The broad terminology of analysis is not precise. Although the word analysis appears as part of the term systems analysis, the former is only one phase of the latter, which implies a total systems approach. Analysis, as used in this article, is roughly parallel to the descriptive aspect of work-study. It implies more analytical depth than the term work simplification, and more variety of approach than operations research. The latter, depending heavily on mathematics, is covered elsewhere in this issue.

This article follows the traditional breakdown of work-study: the study of method, and then the determination of times and costs. This is followed by a look at some of the recent developments in evaluation of library services. Finally, there is a discussion of the role of sampling in the analysis of library procedures. It is assumed that the analyst begins with a clear idea of the administrative and physical organization of the library, as represented by organization charts, policy manuals and personnel job descriptions.

The purpose of method study (method analysis, motion study) is to set forth in detail the steps of a procedure and the sequential and other

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relationships between them. There are two basic categories for study. First, one may analyze the person or machine creating the product. This category is most often used when a highly detailed description of operations is wanted. Second, one may study the product being created, such as forms, files, catalog cards or book labels. Many of the standard techniques of methods analysis are applicable to either approach.

The chief technique employed by the methods analyst is the flow chart, which indicates graphically the sequence of operations upon data. There are two general types. The flow process family of charts is appropriate to record essentially repetitive tasks, which allow for few alternatives. However, where procedures contain many possible alternatives (subprocedures), a decision flow chart is often more appropriate.

Flow charts also differ in their level of detail. Analysis normally begins with a gross breakdown, giving an overview of the library, department, section or function. Succeeding charts increase the number of steps. If the detail is still not sufficient, then each step of the chart is treated as a new task to be analyzed. This process continues until the amount of detail achieved is sufficient for the purpose for which it is to be used.

Flow process charts, as mentioned above, give a picture of the steps in a relatively repetitive process. The steps are numbered serially, and classified according to whether they are operations, transportations, inspections, delays or storages. Distances, and often times, are recorded. These charts are especially effective at showing up excessive movement of people or material. To this end they are sometimes accompanied by a flow diagram. This is simply a scale diagram of the work area being studied, with the actual movement from work station to work station indicated as lines.

Sometimes it is desirable to concentrate attention on a repetitive procedure being done at a particular work location, such as a desk or a charging machine station. This sort of study is usually called operations analysis, and is carried out by means of an operations chart. Such charts use essentially the same symbols and classification of steps as a flow process chart, although they chart each involved body member separately. Thus in two-handed activity the movements of each hand will be shown and correlated. If need be, even foot and eye movements may be recorded.

The basic flow process chart is designed to follow only a single per-
son or product. Sometimes, however, it is necessary to describe work performed by a person whose work is coordinated with one or more other persons or machines. For this purpose so-called multiple activity charts have been developed. The gang process chart, a variety of flow process chart, allows the analyst to describe activities requiring several persons—for example, a large scale shifting of books to a new location. The man-machine chart relates the actions of employees and the machines they use. The activity of each person or machine is charted in a separate column and correlated by means of a common time scale.

The decision flow chart is appropriate to record procedures involving several alternative possibilities for action. Such charts consist of a series of standard enclosed symbols representing steps. These symbols contain appropriate descriptive words and are connected to one another by arrows showing the sequence of activity. The key symbol is a question box, which contains a question which can be answered yes or no, and has a yes and a no arrow leading from it. Although such analysis is very useful for manually performed operations, its binary nature makes it of particular interest when considering the possibility of automating procedures.

The decision table, another way of recording alternative courses of action, has yet to receive from librarians the interest it deserves. It consists of a conditional section listing the various possible alternatives, with appropriate cross references to an action section listing the required courses of action for each alternative. Unlike the decision flow chart, which also shows operations, storage, etc., the decision table is concerned only with alternatives. Thus it does not indicate the temporal sequence of a procedure (although a series of tables can indicate a sequence of alternatives). However, for a complex decision with many alternatives the rectangular table format can be more convenient than the long series of question boxes into which such a situation would have to be resolved on a decision flow chart.

Because forms hold in compact form the end results of a large amount of library effort, study of them is of particular interest in library systems analysis. Such analysis will hopefully lead a library eventually to a complete forms control program. A first step is an inventory of all the library's forms and files, which are then analyzed in a variety of ways.

Processing of single copies of a form may be described by a flow process chart. The relationship to each other of multiple copies of a form is, however, better seen by using a variation known as a form process
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chart. Different processing locations are indicated by separate columns. Each copy of the form is assigned a number and its course shown by means of lines and process chart symbols annotated by brief phrases. Since forms processing involves the use of files, it is sometimes useful to center attention on the latter. The (1) files themselves, (2) the work units responsible for maintaining them, and (3) the various standard file management functions (file created, file searched, etc.) may be related to each other in three different two-dimensional matrix patterns (1-2, 1-3, 2-3). Such analysis calls to attention gaps and overlaps with regard to responsibility and authority.

It is important to know the extent to which elements of data (author, title, etc.) are common from one form to another. This may be shown by means of a two-dimensional data structure matrix, with forms in use listed along one axis and the various data elements along the other. Each element is checked under each form to which it applies. A line of checks (or row, if axes are reversed) indicates commonness of data from form to form. The point for initial entry of an item of data may be circled.

Libraries often find that they must design many of their own forms. Another aspect of analysis is, therefore, to examine such forms to determine their suitability for the task for which they are being used. This analysis includes such things as space allocation, data sequence (to facilitate data transfer or use) and preprinting of instructions and other information.

Work measurement (time study) is concerned with determining how long it takes to accomplish a task. Such measurement is necessary to establish fair performance standards and to calculate systems costs. Since it is necessary to have an accurate idea of what to measure, such study usually presupposes a certain amount of method analysis.

There are three major varieties of work measurement: continuous time study, work sampling and diary studies. In continuous time study an analyst with a stopwatch directly observes and records the time required for a given employee to accomplish each step of a particular task done in a particular manner. The situation is complicated by the fact that the employee is usually working either faster or slower than "normal," so that the analyst has to adjust the observed time to "normal time" by a rating factor. Clearly this requires considerable skill and experience. The normal time is then adjusted for worker allowances to make a fair performance standard. This one-to-one observation is useful in the measurement of low level repetitive tasks. However, it is not
well suited to less uniform activity, is very time consuming (and hence expensive), and can easily irritate employees, who resent being timed like rats in a maze.11

This resentment can sometimes be alleviated by substituting work sampling (activity sampling) for direct observation. Where circumstances allow several different workers to be observed by a single analyst, the cost is also lower than direct stopwatch study. Work sampling consists essentially of making random observations of workers and recording what is being done at the moment of observation. If care is taken to follow proper statistical procedures, idle times, the amount of time spent on various activities and performance standards can be calculated within reasonable tolerances.12 One interesting recent work sampling development has been the use of a pocket-sized battery-operated mechanism which emits an audible signal at random intervals. The librarian carries the device on his person and records what he is doing at the moment of the sound.13

At the professional, managerial level diary study (work study) is often the best way to determine the times spent on different activities. A rather detailed list of activities performed by the personnel in question is developed. Then, following an agreed-on procedure, the staff member himself records the time he spends on the various listed activities. If output is measured at the same time, it is possible to compute unit times for it. This do-it-yourself analysis has great potential for professional library work, and should be employed more widely than it has been to date.14

The three general methods described above enable the analyst to measure only the performance of a given worker in a given library. Ideally, however, data collected by one library could be compiled into a catalog of standard motions or tasks, with times assigned to each operation. Another library could then consult this catalog to determine how much time it would take to perform a given task. A small start has been made at determining standard time units for certain repetitive library operations such as pasting book pockets.15 However, a profession-wide effort is required for significant progress embracing broad areas of library activity.

Once times are known it is possible to determine costs. Cost analysis in connection with work-study should be distinguished from cost accounting. The latter is a management tool allowing continuous monitoring of the costs of an existing organization. Its primary value to the library administrator is to help give him day-to-day control over his
library operation. In contrast, work-study cost analysis requires a greater level of detail, and has as its objective the evaluation of various ways of executing operations, to help decide the design or redesign of a given system.

Costs are normally classified as to whether they are direct (labor, supplies) or indirect (depreciation, overhead). The greatest single expense is usually labor. Many librarians would be aghast (if they knew them) at their standard costs per unit of work produced. This standard cost takes into account (in addition to salary) daily nonproductive time (such as coffee breaks), vacation, holidays, sick leave, personal leave, and employer contributions to company pension, social security, and health, hospitalization and other group insurance. Such benefits, even excluding daily nonproductive time, can easily consume fifteen percent of a library’s salary budget.

To consider equipment purchases as current expenditures—a common practice in libraries—distorts the cost picture, for it implies that the usefulness of the equipment will end with the current fiscal period. Normally a piece of library equipment has a useful life of several years. However, it usually depreciates in value over its useful life. There are various depreciation models from which the systems analyst may choose, varying in complexity and in accuracy for a given situation. The book collection, a heavy investment in most libraries, would logically seem to be amortizable, and should normally be considered as such in systems analysis, even when the library’s financial regulations do not allow this in the official budget.

Overhead costs are those which cannot be assigned directly to particular operations. Examples include administrative salaries, building maintenance and repair, utilities, rent, and insurance on building and collection. Overhead costs are commonly allocated in proportion to direct labor costs. This procedure clearly encourages management to work toward library automation wherever feasible.

The library profession has made a small start toward the use of industrial cost techniques such as break-even analysis. This latter technique determines the magnitude of production required to make a particular method of production economical. Below a certain volume, one method is most economical; above this volume, another. A recent article has applied break-even analysis to determine when to photocopy Library of Congress proof slips, rather than to order sets of Library of Congress cards.

For a variety of reasons it is very difficult to find useful cost data in
Valid cost comparisons from library to library are even more difficult than valid time comparisons. Whereas a time standard based on a standard method should be valid in any area so long as the work is the same and the method adhered to, costs will vary according to the labor and other rates for a given region or city, as well as with time.

The principal method for gathering quantitative data for library evaluation has been simple counting. Dissatisfaction with the analytic shallowness of this procedure has led to recent attempts to develop better methods. Between July 1966 and June 1968, supported by federal contract money, the Institute for Advancement of Medical Communication attempted to “develop methods for collecting objective data suitable for planning and guiding local, regional and national programs to improve biomedical libraries and the biomedical information complex.”

This team was able to develop an inventory of library services to individual users, a document delivery test (to determine the speed at which desired documents can be provided), tests for verifying citations and answering simple fact questions (to test a library’s capability for basic reference service), and a mechanical sampling device (mentioned earlier in connection with work sampling) to encourage the collection by staff of reliable data on some major services (use of the card catalog, self-service photocopying, etc.) that until now have gone largely unmeasured except in one-time studies. The document delivery and basic reference tests are based on random samples of citations, underscoring the increasing importance of sampling for libraries. Although it is true, as the institute team states, that many of the techniques resulting from this work are also applicable to other types of libraries, the specific tests thus far developed are of use primarily for academic medical libraries.

In July 1966, John I. Thompson & Company accepted a contract with Picatinny Arsenal, U.S. Department of the Army, to perform a study aimed at developing “criteria for evaluating the effectiveness of library operations and services” under the Army Technical Library Improvement Studies (ATLIS) program. One approach suggested is a review of existing library statistics on the basis of correlation analysis to “provide certain insights into current practices that could form the basis of effectiveness criteria.” A second idea is the use of a “paired-comparison” analysis to determine which of the many well-known management techniques (methods study, cost-effectiveness analysis, etc.) is the most appropriate for study of given library services and operations. A third
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approach requires the librarian to prepare, based on his library's mission statement, its goals and objectives, and the theoretical services and operations required to meet these goals. Then, by means of "utility analysis," he compares this theoretical situation with the real-life situation in his library. Although it contains some interesting ideas, this study (see Additional References) is not easy reading, and requires a fair amount of mathematical sophistication. It seems unlikely that it will have any widespread impact on the library profession in the foreseeable future.

Random sampling, already mentioned in connection with work sampling and the evaluation tests developed by the Institute for Advancement of Medical Communication, is a very powerful technique for the analysis and evaluation of library procedures. There is no doubt that the vast quantities of data to be analyzed in libraries will increase its future use. All library education should include some knowledge of sampling, not to make librarians expert samplers, but to spread an appreciation of the potential of sampling among the profession as a whole.

Sampling is a compromise short-cut. We accept some tolerance in our answer in return for having to consider only a small proportion of the available data. The less tolerance we accept and the more insistent we are that the true answer is within the tolerance, the larger the required sample.26

It is possible to take random samples of either variables or attributes.27 In the former we take into account the magnitude of some variable character for each of the objects or individuals observed. In the latter we merely note the presence or absence of some attribute in a series of objects or individuals and count the proportion or percentage which do or do not possess it. An example of sampling a variable would be determining the average number of days between the borrowing and return of library books. Work sampling is an example of attribute sampling.

Selection of the items to be included in the sample may be made by means of tables of random digits or permutations.28 However, for a sizable sample it is much more efficient to do this by means of a computer. The numbers so generated are called pseudo-random, as they are computed in a completely deterministic way.29 However, statistical tests have shown them to simulate true random numbers closely enough for practical purposes.

Sampling applications cover the gamut of library work: files, collection, staff and users. Files include the card catalog,30 shelflist,31 and cir-
Library collections are usually sampled by numbering locations, rather than books. If a unique number is assigned to each possible book location, then each book will have a unique number associated with it. Staff may be analyzed by means of work sampling, which has already been discussed under time study. Similar random-time techniques may be used to sample library users.

In conclusion, there is no shortage of appropriate techniques for the analysis of library operations. Many of those described here require no particular mathematical background, and are essentially extensions of common sense. Strengths and weaknesses of various techniques have been called to attention, and wider use by librarians of certain ones has been encouraged. This issue of Library Trends properly emphasizes analysis as the prelude to systems design. However, the librarian undertaking such analysis will also discover that, like virtue, it is to some extent its own reward.

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Determined Requirements for a New System

JAMES F. COREY
FRED L. BELLOMY

The requirements analysis phase of a complete systems analysis brings together the analyst (the innovator) and line personnel (who may harbor anxiety toward innovation). Through many hardworking sessions, the analyst is supposed to come to understand the procedures utilized by line staff, to appreciate the problems encountered, and to elicit suggestions for ways to improve things. Line personnel, impressed by the empathy of the analyst, shed their fears, roll up their sleeves and become allies and partners in the process of determining requirements. In a climate of mutual respect and admiration, line personnel and analyst consider not just the desires of the studied department, but the greater good of the whole library. The analyst then departs for a few months, only to return with a perfectly tailored system that is easily installed and works to the immediate satisfaction of all using it. This is certainly close to the picture one gets from the literature, including some of our own previously published works.¹

Now let us go to the real world. Requirements analysis work, in the classical sense described in textbooks and articles, is seldom done. When it is, it may be hampered by difficulties and fail to achieve desired results. Library analysts, foreseeing the problems inherent in a classical analysis, have devised shortcuts which work, which enable management to make decisions, and which have become commonplace. The remainder of this section will discuss the reasons why departures are made and why studies fail even when the best efforts are made to do an ideally planned study. The following sections of this article will describe the classical approach and contrast it with the authors' per-

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sonal experience and observations of how requirements have been established by real people working in the real world. Then several actual modes of departure from the classical method which offer some hope for success will be summarized. The reliance upon personal experiences and observations is occasionally necessary because of a lack of published information about many actual requirements studies. A survey of the literature yielded several publications on "how to" conduct a requirements analysis and some reports of actual studies. (See Additional References.) The reports on actual studies tended to be the more thorough studies. The shortcut techniques are not often documented.

The requirements analysis may fail because it focuses attention on the need for actions which the concerned library staff really does not want to take. This happens when new systems or changes in existing systems are proposed which may cause librarians more work or require that they learn new skills in areas where they currently have little interest. Involvement in the process of change via the mechanism of the requirements analysis works really well only for those who see their preconceived ideas and goals being integrated into the overall planning. Obviously, with major new systems, all preconceived notions just cannot be incorporated, and a single librarian's expressed discontent can catalyze widespread fear and mistrust of the change-makers and their allies.

Where development costs are high (as is the case for many automated systems) requirements analyses have been expanded in the attempt to encompass multiple institutions in order to share the costs. Attempts to reach consensus on a common course of action involving a significant degree of behavior change in several relatively autonomous organizations invite failure before the discussions even begin. A careful systems analysis often reveals an optimum course of action for the overall operation which produces suboptimum results and possibly, degraded performance, for some or all of the participants. If, like typical defense or aerospace systems development efforts, we were dealing with mechanical systems or groups of people yet to be organized, the problem of suboptimization of some elements of the total system would not be objectionable because there would be no one to object. But that is not usually the case with systems development efforts for our libraries. Intelligent people, working in relatively stable and tradition-based environments, are told by well-meaning analysts that they must change their behavior in a way which seems unnatural, uncomfortable,
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and perhaps even irrational, for the greater benefit of the larger organization.

If approaches which depend on achieving a consensus among working librarians have been less than spectacularly successful, then it is reasonable to give careful and serious consideration to approaches which rely on the judicious use of power. Writers in the past have tended to use a great deal of restraint when discussing this Machiavellian aspect of systems work. The literature is replete with Milquetoast references to "the need for top level management support of any major systems effort." The key factor in assessing the effectiveness with which power is used seems to be the decisiveness with which the chief executive acts. Of course students of management practice have been saying things like this for years. What has been lacking in libraries is not the will or determination to act, but knowledge and experience of workable strategies for implementing successful change. Naturally, a manager is reluctant to act when his or her advisors present conflicting views, and the results of many requirements analyses foster such conflicting opinions.

Where does this state of affairs leave those who believe that the application of new technologies to the problems of library operation does indeed make sense and should be pursued? One could, of course, stop tampering with established organizations and concentrate attention on commercial developments and new libraries.

When commercial organizations (e.g., Richard Abel Co., Information Dynamics Corporation, BRO-DART, etc.) develop systems requirements, they do not even attempt to satisfy every potential user of the system they are developing. They know that they cannot please everyone! Those they do not please will merely ignore them. In cooperative efforts, however disenchanted people may become active or subversive opponents of the development.

Similarly, the opening of a new library (e.g., the University of California-Santa Cruz Library) is a particularly opportune time for the introduction of new technology. Only staff members sympathetic with the application of modern technology to libraries need be recruited. In any case, everyone joining the organization expects that they will need to make some adaptations of their previous behavior to the requirements of their new organization.

However, the answer has not been to abandon change in established libraries and leave it up to the new libraries or the commercial firms.
The solution for many practical working analysts is to avoid the morass of the theoretically perfect (hence, interminable) requirements analysis is selected.

**The Model Study—A Summary**

The object of developing a thorough understanding of goals, present methods and possible alternatives is to enable the decision-makers to make the best possible choice among alternate courses of action. Of course they can and often do make choices based on more intuitive criteria, but ideally a thorough study will precede the selection of a new system. A thorough study of requirements for a new system is a multi-step process. The phrase “requirements analysis” does not have consistent meaning in the literature of systems analysis. In order to describe how the phrase varies in meaning, we will start with a list of the steps one might find in an ideally planned analysis of requirements. These steps are shown in figure 1 along with several hypothetical and real life strategies for modifying the ideal study. As a matter of semantics, requirements analysis could, in different contexts, encompass all, fewer or more than the steps shown in figure 1. Even the order in which steps are taken will vary from one analysis to another.

To a certain extent the steps named in figure 1 are arbitrarily divided. In actual practice, no clear division between steps occurs. The boundaries between the formulation and evaluation of alternatives (steps 8 and 9) and the statement of goals, objectives and requirements (steps 2, 6 and 7) are especially blurry.

The application of any of the first four strategies (A-D in figure 1) leads to a set of detailed requirements for the new system while either of the last two (E-F) presumes that the selected system will satisfy enough of the intuitively known requirements to warrant its adoption.

Requirements analysis ends either when all alternatives have been rejected and the old library procedures retained or when a new alternativ study.

**Description of the Steps**

There is no one discrete point at which one can say the process of requirements analysis actually begins. The moment an organization begins to examine its basic objectives the process has begun in the most basic sense. Figure 2 shows several levels in the development of objectives into ever more specific statements. The level at which the statements become less philosophical and more operational might be con-
Delineate scope of study and resources
Deduce requirements
Formulate alternatives
Evaluate alternatives
Select alternative
Begin system design

Fig. 1. Strategies for a Requirements Analysis

sidered the boundary between objectives and requirements. Figure 3 shows the relationship between some hypothetical objectives and requirements to illustrate one example of this boundary.

To coordinate this chapter with the others in this issue of Library Trends, the description of requirements analysis will be restricted to steps 5 through 10. The following paragraphs will further clarify the relationship among the several steps identified as part of the ideal requirements study.

RE_EVALUATE THE SCOPE OF STUDY (STEP 5)

The scope of the requirements study is invariably limited. An example of this limiting is shown in figure 3. Often the impetus comes from management, either because there is an obvious pressing problem or because a manager's intuition tells him that the potential for improvement in one part of the library is particularly great. At other times, the impetus comes from the analyst, either because early results of his analysis reveal a potential for improvement in one area or because he recognizes that a study of the whole library would be much too large a task to handle effectively.
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Fig. 3. Relationship of General and Specific Objectives

While an opportunity for improvement may be missed as a result of restricting the scope of the analysis, the results may be worthless if too much is included. An all-inclusive study might have to treat some steps in a cursory way, or if done thoroughly might take so long to complete that it would be obsolete by the time it is done.
Ideally one would not state the objectives of a new system without taking into account the objectives of the organizations within which the system is to operate. Just as a library's objectives must contribute to the achievement of the parent organization's objectives, so too must the objectives of the library departments contribute to the achievement of the overall library objectives. A logical approach is to work down in hierarchical fashion beginning with the highest level organization and ending with requirements for a specific system. In general, the analyst works with top library management to articulate policy, with middle management to formulate objectives, and with first line management to specify requirements.

The results of analyzing the existing system may imply system objectives which are overlooked when working down the hierarchy alone. Working up the hierarchy from procedures to requirements to objectives has the benefit of making procedures justify themselves. Since working both up and down the hierarchy to identify system objectives can occur simultaneously, it is difficult to separate this aspect of the analysis into discrete steps.

The purpose of developing requirements early in the requirements study is to establish criteria for selecting one of several alternate means for achieving a set of systems objectives. An example of simplified requirements is presented in figure 3. To be useful in evaluating alternate systems, the requirements must be stated in their order of priority. It is a matter of management policy to decide the relative order of importance for a set of itemized requirements. The list may very well contain low priority "requirements" which are in reality only desirable; that is, an alternative which does not include a "desirable" still might be selected because it better satisfies the higher priority requirements.

It can be quite a job to get the desirables identified as such, rather than as requirements. When a new system is being contemplated, both management and line staff are eager to elevate desirables to requirements. At a later stage, namely the evaluation step, selling points can be made for alternatives that easily (cheaply) produce desirables.

The development of a list of requirements (and desirables) is a highly error-prone process. The analyst may deduce many of them from policies and objectives specified by management. Some may be
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extracted from policy and procedure manuals or from the analysis of current systems characteristics. Many of them will be extracted from the heads of line staff who just “know” what they want a new system to do. One reason the process is error prone is that past outputs invariably are equated with requirements. If such “requirements” go unchallenged, any resulting new system will have the old faults designed into it, with the dubious benefit of producing a new system which may do unnecessary things more efficiently.

Requirements must be stated for all individual inputs and outputs and for the system as a whole. Inputs and outputs are of two types: material items (books, serials, maps, etc.) and instruments of communication (invoices, request cards, verbal requests, etc.). For each input of either type, the requirements must state the frequency (average and peak), the processing to be done, and the final disposition. For each material output, the requirements must state destination, timeliness and physical condition (property stamped, bound, marked, etc.). For each communication output, the requirements must state the data elements to be included, the average and peak lengths of each data element for written communications, destination, medium (verbal, written) and timeliness.

Once requirements for individual inputs and outputs and the system as a whole have been stated, the juggling of priorities begins in earnest. Some requirements may be in conflict; i.e., the requirements to produce an output within two days of the arrival of an input may be able to be satisfied only at a cost beyond an overall system cost constraint. The less important must be sacrificed.

There are no fixed priorities which invariably apply to establishing requirements in every library systems development effort. The variables are so numerous that it is not practical to predecide for all situations that costs or patron satisfaction or any other factor should dominate choices. Manager’s intuition, funding limitations, political considerations, external pressure, physical constraints, the talents of available personnel, agreements with other agencies or institutions, and (possibly most important) just plain personal preference, all may play a role in establishing the relative importance of various requirements.

The process of listing characteristics wanted in the new system in priority order is concluded when someone in authority declares that features below a specified item on the list shall be considered desirable only, and that all of those above that point shall be considered essential requirements. When management has approved the formally docu-
mented list, the analyst may begin the task of finding alternate systems approaches which meet the requirements.

FORMULATE ALTERNATIVES (STEP 8)

“Alternatives” are the significantly different ways of satisfying requirements. Some alternatives may be totally automated, some may be completely manual, and others may be mixed. Some may rely on techniques and technologies previously used in libraries while others may incorporate procedures which appear radically different or unfamiliar. One alternative is to do nothing, i.e., retain the present system.

The formulation of alternatives is probably the most challenging aspect of systems work for the analyst. There are an infinite number of possible ways of carrying out any library function. But only a very limited number of them will meet all of the essential requirements. Competitive alternatives can be discovered empirically via surveys of other libraries, but procedures vary greatly from library to library, making it the exception when another library’s system will fit perfectly. Almost certainly the analyst will have to hypothesize a small number of further alternatives based on an instinct for the overall cost/effectiveness of each.

Alternate systems approaches must be described in enough detail that the costs and effectiveness of each can be reasonably well predicted. As an aid to evaluation, the formulation of each alternative system should be documented in a working paper which expresses the concepts embodied in the proposed alternative. This working paper is called the system concept document. There is one system concept document for each alternative to be evaluated. The first section of the document contains a narrative description of how the system would work when operational. Work flows and volumes are described with special attention to new procedures. New equipment is described; new job skills are noted; and the projected lifespan of the new system is forecast. The second portion of the system concept document is devoted to developing and installing the new system. Changes in library organization, personnel and equipment are described. Schedules for retraining personnel and installing equipment should be included. If computer-assisted procedures are part of the new system, a schedule for the development of the programs is also included. The third part of the document is for evaluation based on costs and benefits. But the evaluation cannot begin until after the analyst has received agreement from all
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levels of management that the proposal is understood and contains an adequate degree of detail.

EVALUATE ALTERNATIVES (STEP 9)

The process of evaluation is both science and art. Ideally analysts would like to establish a single objective measure of the overall cost and effectiveness of each proposed alternative. The list of gross requirements (and desirables) might be quite long and the alternatives will certainly vary in the extent to which requirements are satisfied. Attempts to develop a single quantitative measure of desirability are always subject to wide (and justified) criticism. One approach is to give each of the evaluation factors a weighted point value. That alternative which meets the combination of requirements and desirables with the highest sum of points "wins." However, unless the winning approach is clearly far superior to the others and also is the intuitive choice of nearly everyone, the weighting factors undoubtedly will be questioned.

The process of evaluating alternatives is sometimes called a trade-off study. Benefits of each alternative are compared with the total cost of ownership (i.e., amortized development costs, operating and maintenance costs). Increased effectiveness benefits of a new system are generally obtained at the expense of reduced cost benefits and conversely. Naturally, there are some happy exceptions, but in general one must be traded for the other. The trading process itself boils down to the personal preferences of the person who makes the final decisions.

Data collection and organization must be as systematic as the analyst's skills will permit. Some of the data will be quantitative (costs and work load capacities are examples) and others will be qualitative (patron acceptance, training requirements and staff acceptance are examples). The qualitative are by far the hardest to evaluate, but at the same time may be the most important. In most studies, the quantitative factors must be favorably evaluated as a minimum condition of acceptability before the qualitative factors are then brought in to swing the decision. The quantitative evaluation will indicate what work loads can be handled by the alternative at what cost. If costs and productivity are within reasonable bounds, then the quality of the benefits is considered.

Figure 4 shows how the characteristics of alternatives typically are summarized and displayed for evaluation. Three approaches for com-
Comparing systems are illustrated. First, the presence or absence of a mark (X) may indicate whether a system has a particular characteristic (requirements 1-3). Second, it may be shown how well (low, medium, high) each system meets a particular requirement (requirements 4-6). Finally, systems may be ranked according to how well they satisfy a requirement (requirements 7-9). Clever analysts will think of other discrete evaluative techniques, but simplicity should be the essence of every technique.

Such a trade-off matrix as illustrated in figure 4 can, of course, be used for summarizing various aspects of costs and other quantitative performance characteristics as well. However, quantitative evaluations of alternatives are more likely to require extensive and more complex analyses before summary is possible.

The two most frequent quantitative characteristics to be measured are costs and volumes processed. If a cost accounting system has been established in the library, costs and volumes for the current procedures already will be known. The requirements analysis can focus its energy on the alternative proposals. But if cost accounting is not built into the operating procedures of the library, a study will be needed. The techniques of cost accounting are treated elsewhere in this issue.

Fig. 4. Example of Trade-off Matrix for Hypothetical Systems Alternatives

<table>
<thead>
<tr>
<th>No.</th>
<th>Requirements or characteristics against which systems alternatives are to be evaluated</th>
<th>Alternate System Approaches</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>A</td>
</tr>
<tr>
<td>1</td>
<td>Requires new computer</td>
<td>X</td>
</tr>
<tr>
<td>2</td>
<td>Solves patron queuing problem</td>
<td>X</td>
</tr>
<tr>
<td>3</td>
<td>Produces statistics as a by-product</td>
<td>X</td>
</tr>
<tr>
<td>4</td>
<td>Probable patron resistance</td>
<td>High</td>
</tr>
<tr>
<td>5</td>
<td>Staff training requirements</td>
<td>High</td>
</tr>
<tr>
<td>6</td>
<td>Dependence on outside commercial service</td>
<td>High</td>
</tr>
<tr>
<td>7</td>
<td>Staff familiarity with technology</td>
<td>6</td>
</tr>
<tr>
<td>8</td>
<td>Meets intent of management policies</td>
<td>1</td>
</tr>
<tr>
<td>9</td>
<td>Compatible with other library systems</td>
<td>1</td>
</tr>
</tbody>
</table>

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Costing hypothetical alternatives poses an interesting challenge. If an alternative does not exist, how is it to be measured? There are two ways to cost hypothetical alternatives. In the first method the alternatives are taken one at a time and contrasted with the current system. An alternative, as documented in a system concept working paper, is culled for cost differences between it and the current system. The differences represent increases or decreases in costs. Some old costs are replaced by new ones.

The second method does not calculate cost relative to current procedures. Rather, the procedures envisioned by the proposed system are costed by means of independent estimates. Usually the new procedures are subdivided into smaller components (call them activities) and the activities are costed. Aggregate costs for whole procedures are calculated by summing the costs of the activities that make up the procedures. In some cases, accurate estimates of activity costs are available, as for instance, a key-punching task. Other activities will be at the other end of the accuracy spectrum—in short, they will be wild guesses. One of the best attempts made to cost a hypothetical system using this method was done by Leonard et al. in the Colorado Academic Libraries Book Processing Center proposal. The activity costs were derived mostly from actual work measurements in existing library procedures. The use of this technique in Hayes and Becker is much less convincing because the activities in the alternate systems are too briefly described.

Development (investment) costs must next be estimated. These costs should include retraining costs, design costs and installation costs. If an automated system is planned, there are also costs for data conversion and possibly for equipment needed during the development phase. Costs to run parallel operations are part of installation costs.

If all the costs of an alternative are within reasonable bounds (as determined by the library administrator) and the alternative can handle current and projected work loads, then qualitative factors (benefits) come into play again. The library administrator may or may not rely on the data in the trade-off matrix (figure 4). But the evaluation nonetheless, will be based on qualitative factors. Hayes and Becker sum it up when they say that the qualitative issues are "so deeply imbedded in the very concept of library service that they can be answered only by the professional judgment of the librarian. At best, the system designer can clear out the underbrush of extraneous issues—those that can be quantified—so that the alternatives are presented free
SELECT ALTERNATIVES (STEP 10)

The selection of a new system from proposed alternatives is not always a discrete step. Normally, the library administrator will have been keeping abreast of the alternatives being considered. He will have gotten prior indication of the relative order in which the alternatives are likely to finish in the evaluation process. He will be prepared with his own set of goals and priorities to superimpose on the trade-off matrices prepared by the analyst. The decision may be made quite quickly, or elaborate reviews may be held with the whole library management team in attendance. In the latter case, the process is likely to consume a considerable amount of time.

Selecting an alternative means making a commitment to it. Making a commitment means selling the merits of the new system to the staff while at the same time helping the staff to make a smooth positive adjustment.

REAL STUDY CONTRASTS

The eleven steps listed in figure 1 represent a theoretical level of achievement which is rarely attained in actual practice. Rarely are all steps taken and sometimes very few are included in the determination of requirements. Further, each analyst's devotion to thoroughness and detail is uneven for whatever combination of steps he or she does choose to include in the analysis.

There are many reasons why this happens. One is the limitation of human intelligence and human endurance; no one person is so talented as to be equally qualified in all the skills necessary to carry out all the steps with the same degree of competence. Even a highly talented person could not do a moderately large study in a reasonable time and also be completely thorough at every step. The alternative is to hire a staff of experts who are specialists in each of the needed techniques. But, well qualified teams have their limitations too, and only the well-funded programs can afford them.

There are other more mundane reasons, however, for achieving less than theoretically complete requirements analysis. Library management may already have a specific problem identified and a solution in mind. The job left for the systems analyst is to do the detailed requirements study in order to justify management's preselected alternative.
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Figure 1 shows five typical departures from a complete study. All five are defined in terms of the omission of steps. These are the kinds of departures to be discussed. Other kinds of departures such as skimping on particular steps, cycling through combinations of steps several times, or performing combinations of steps in parallel will not be discussed further.

All efforts to change existing library procedures must be backed by power in the form of authority to carry out the change to its conclusion. When a complete and thorough requirements analysis is accomplished, the analysis itself theoretically is the instrument which convinces management to exercise power and effect change. As fewer steps are included in a requirements study, the persuasiveness of the studies themselves ought to diminish. Management's use of power must be justified in other ways. The influence of strong personalities or external political pressure assumes increasing importance as the quality and objectivity reflected in a requirements study diminishes.

This point becomes especially important where library consortia are involved. The power to force change in most cases does not exist. No single higher administrative authority over all the cooperating libraries exists or, if it does, it is only at the level of the state government where it is not asserted. Unless libraries work out voluntary methods for implementing change through the effective use of power at lower levels, the use of power by higher levels of authority may become a prominent reality.

Strategy B from figure 1 is so close to a model study that, if done thoroughly, it should convince management of the need to act. The only significant departure from the model is the failure to formulate broad library policies, goals and constraints. Constraints are usually known even if not stated. Honest administrators admit that basic goals are elusive and at best they are difficult to conceptualize even without trying to state them explicitly.

Strategy C can be as convincing as B. The results of the analysis read well because the analyst has made an effort to understand the current procedures and objectives of any new system. The proposed new system is shown to be capable of "doing the job." The dangers of designing a new system based on strategy C are that the new system could fail to handle future work loads (step 3 missing) or it might cost more to use (step 9 missing). Computer-assisted procedures, utilizing the generally expandable power of the machine as they do, have less often failed to handle increasing work loads. Hence the risk of skipping step
3 is less when computer-based alternatives are contemplated. But these same computer-assisted alternatives have often cost more, showing that the real danger of strategy C is in omitting a careful evaluation of costs when computerization is under consideration.

Strategies D, E and F begin to depend less on the requirements analysis study portion of the total systems analysis methodology. There are other ways to know what to do than through the initiation of a formal study. (In fact, it is probably wasteful to launch study after study in library after library for every contemplated change. Some knowledge must be capable of extrapolation or transfer.) The diminishing role of the requirements study must be accompanied by the concomitant increase in knowledge and power from other sources. These three "practical" strategies have been used with success and depend in part for their success on the effective use of power. We will call these three approaches invention, replication, and transfer. For each of these to work, an executive with the power to act must have unquestioning faith in the key person whom he directs to bring a new system into being.

The invention approach relies on the existence of a genius who combines the knowledge of what needs to be done with the knowledge of how to do it. This one man, from his many years of experience with a particular library function, intuitively knows the requirements and bases his design of a new system on this knowledge. He may talk to users and ask them for advice regarding requirements for the new system, but in the end it is his own judgment that will determine what is to be done.

The replication approach recognizes the existence of the many highly successful mechanized library processing operations around the country. While none of these systems will be perfect for another institution, the presumption is that one or more of them will come close enough to meeting requirements to warrant their adoption without significant modification. Almost no requirements analysis is performed because the decision to replicate a particular system is based on pragmatic considerations. It is entirely possible that the library's most critical problem, which may or may not be known, may or may not be solved by the installation of the new system. Examples of this approach include approximately thirty libraries throughout the country which replicated the original Montclair circulation system based on the use of IBM punched cards.

The transfer approach focuses on a particular individual who has
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previously installed a system elsewhere which seems to meet a library's current needs. For example, a new head of acquisitions "knows" that a mechanical accounting machine system that he used in his previous library would be better than the smeared ledgers that he finds in his new library. The critical element in this approach is the person who has intimate knowledge of the system, with the desire and determination to replicate it at another installation. There is no way to estimate accurately how often this happens. It probably does not happen more frequently because we have all been encouraged to believe that no major systems development effort should be commenced without an exhaustive (i.e., expensive) systems requirements study, the results of which have the unanimous support of all potentially involved library employees.

The replication and transfer approaches can also be adopted after a complete and thorough requirements analysis, of course. In that case, the approaches are really approaches to implementation rather than requirements study.

The study strategy adopted may reflect the mode of implementation anticipated. Two modes are contract service and pilot testing. The first approach is where the library contracts with an outside agency for service. The contract may be negotiated only after a thorough requirements study, or it may be entered into after a brief analysis where other alternatives were not considered and little or no evaluation was done prior to signing the contract. Where the contract requires a minimum commitment on the part of the library (low monthly cost and easy cancellation terms) it is often a sensible course to forego an elaborate requirements study. Hence it frequently happens that a contract is signed after a requirements study of the type shown as strategy E.

The pilot test approach to implementation also allows the requirements study to be shortened with little risk. As before, a pilot test approach may be used even though a model requirements analysis was conducted; in fact, it often is. But there are situations where the pilot test was seen as an alternative to a model requirements analysis. The new system is tried only for a subportion of the procedures that would be impacted by the complete operational system. For instance, the new system might be installed at a branch instead of the main library, or it may be tried on just monographs and not serials. The pilot is watched closely and after a preestablished period of time, the decision is made to convert fully to the system or scrap it. Pilot projects have the merit

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of offering empirical evidence of a system’s suitability for meeting library requirements. Hard data are superior to the predictions of the most highly credible studies.

Another type of pilot test, the one that is regarded as a shakedown period for the committed installation of a large system, is not the type that can substitute for a requirements study, which is characterized by a totally different mental attitude. The former method, often called the back door approach, is a favorite of many analysts. The analyst knows of a good system operating somewhere or has a good idea of his own and gets management approval to try it. If it works, fine; if not, little was lost. If it works well enough, it can even be extended to other parts of the library or branches.

The above strategies are representative of actual approaches to determining requirements for a new system. The classical method requires the most time, money and expertise. The less thorough strategies seek to strike a balance between available resources for conducting the study and information needed by management to take wise action.

The use of systems analysis, at least in the area of library requirements analysis, has, to date, achieved less than dramatic results. Most successful has been the description of existing systems in libraries using systems analysis methods. But the formulation of alternatives and the cost/benefit evaluation of both existing systems and hypothetical alternatives seldom has been done thoroughly.

It is not clearly demonstrated that requirements analysis studies need to be done thoroughly. Doing a thorough job can be very expensive and time consuming. The results are often viewed with scepticism especially when a radically different set of procedures are envisioned. For this reason, the analysis does not guarantee a clear picture for management.

Persons with years of experience in library operations plus an awareness of other methods for “doing the job better” may be in just as good a position to know the best course of action as the library administrator reading a thick requirements study report. The reader is invited to think back to any major decision about which he has knowledge (such as the decision to open the stacks, start a new branch library, or switch from Dewey to Library of Congress classification). How many were preceded by detailed studies? How many worked out satisfactorily even without the study?

A comprehensive requirements study is not necessarily a prerequisite
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for effective action in libraries. The correct strategy for any contemplated requirements study is precisely whatever management needs at the time to make a good intuitive choice among alternate courses of action—no more and no less.

References


7. Ibid., p. 166.

ADDITIONAL REFERENCES

ON REQUIREMENTS ANALYSIS

"HOW TO" LITERATURE


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REPORTS OF ACTUAL STUDIES


Application of Systems Analysis in Designing a New System

THOMAS MINDER

Modern systems analysis was conceived and born in the computer field. All computers depend on detailed instructions at the elementary level. Machines built before the mid-1950s had no internal programming aids, so the programmer was forced to think and work at this same elementary level. Even the simplest problem was prone to error as it was being planned and coded. Programmers naturally looked for tools and techniques that would reduce this error rate; they called this collection of tools and techniques "systems analysis."

Others, particularly industrial engineers, saw the similarity between their own "efficiency" tools and systems analysis, which they adopted and expanded into noncomputer areas. Systems analysis evolved into the analysis, design, evaluation, and control of complex systems. However, engineers restricted its development to the scientific method. By the early 1960s it had become an engineering discipline.

During this period, the library profession began to feel the need for new tools and techniques to control its growth. This was especially true in the universities. Dix's description1 of university libraries during the two decades following 1950 clearly shows the need for new management tools. The newness of systems analysis and the special nature of librarianship provided a unique opportunity for material enrichment as the two fields began to come together. Librarianship cuts across many fields, but it saw itself as a humanistic or behavioral science. Systems analysis as developed by engineers was a natural science.

The library profession had a choice: it could have accepted systems analysis simply as an engineering discipline and applied it to that narrow range of engineering-oriented library problems; or it could

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have looked at the fundamental properties of both disciplines and then expanded each to include properties of the other. The first option would have left both untouched; the second would have caused changes in the basic nature of both.

The first option was selected. Librarianship has not changed as a result of using this new tool, and it has contributed little to the development of systems analysis. In fact, systems analysis has suffered because its development beyond engineering type problems has been very slow. Librarianship, a field of many disciplines, could have done much to make systems analysis a field of many disciplines.

This limited use of systems analysis has not been all bad. In fact it has given the profession a chance to accumulate some much needed data about itself. Items listed in the Additional References are rich in this kind of data; they are noted as merely a sample of studies that have been reported. Useful items can also be found in library periodicals and technical reports.

Although we may not have yet reached the peak in applying systems analysis to library problems, we may be rapidly approaching a point of diminishing returns. How many dissertations in the 1970s will repeat Ben-Ami Lipetz's excellent study of the Yale catalog, merely adding another decimal place to what he has already said?

There is little need to write about procedures now being used in library systems analysis. Many of these are discussed elsewhere in this issue. Some general handbooks cover the techniques rather well as do the citations noted in the Additional References. Instead, one should focus attention on underlying principles and implicit processes used by analysts, concentrating on the role of the analyst in the inquiry process.

INTELLECTUAL LEVELS

The human mind works at many levels. The mechanical semiconscious level is used when operating a piece of familiar equipment. Creativity and abstract thinking are needed to contemplate the existence of God and man's reason for being. Man has recognized these levels and has designed many of this activities accordingly. Educational systems, job classifications and levels of authority tend to fall into intellectual level categories. Systems analysis is no exception. It is found among the activities on the academic level. This section will be a discussion of this level, so as to gain some understanding of the way analysts think in their day-to-day work.
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Professional practice and academic study are carried out on three distinct levels—operational, problem-solving and philosophical. These tend to correlate with the three basic degree programs—baccalaureate, masters, and doctoral. The person who has completed the first level is expected to have an understanding of the tools and techniques needed to keep the profession in a stable operating mode. He is expected to creatively apply established rules, procedures, theories and laws to the discipline, to keep it functioning at its present level.

Operational level thinking is almost always taught at the undergraduate level. Librarianship is an obvious exception. When librarianship moved up to a masters program, the courses simply moved up. The academic void at the undergraduate level was supposed to have been filled by the liberal arts program.

There has been an increasing concern for some years over this form of library education. The new ALA policy on education and manpower is an attempt to adjust present practices in the direction of other disciplines.

This inconsistency has also had an effect on library systems analysis. The basic tools and techniques of systems analysis (at the operational level) are common to all disciplines. These are taught by other disciplines, especially industrial engineering, at the undergraduate level. Library educators, on the other hand, are being forced to teach the same things at the graduate level. The fact that library systems analysis training is taught at the wrong level does not mean that analysts only think at the lower level. Indeed, they are forced to think at the problem-solving level whether or not they have been trained to do so.

The problem solver can be described as one who creatively applies basic principles to the solution of problems. He is the one who questions current operating procedures and attempts to make significant changes or improvements in those procedures. He is the one who designs new systems. As a corollary to these analytic and synthetic activities, he develops and runs evaluation and controls subsystems. He is a practical person with a questioning mind. He is reluctant to accept the discipline's current status as either good or adequate. Yet he is not trained to question the philosophical foundations of the discipline.

A person at the third level is trained to question the very foundation of the discipline. One such question in librarianship might be, "Does the static nature of recorded information and the dynamic
nature of knowledge lead to an unbridgeable gap in classification theory objectives and classification practice?" Although this question might be motivated by day-to-day problems, its answers are likely to be philosophical.

The system analyst, when working as a professional person, is in the second category. The way problems are defined, tools selected and value judgments made, sets him apart from both the operational and philosophical levels, and from other professions working on the same problems. He may, indeed, spend much of his time doing routine data gathering and synthesis, but his professional work occurs at this higher level.

It should be noted that the intellectual levels and academic categories as described are consistent with the ALA policy on education and manpower and two statements from the Council of Graduate Schools in the United States. Librarianship as taught and practiced today must fall in line with these levels if it is to integrate and use other disciplines, such as systems analysis.

RESEARCH METHODOLOGY

The scientific method of finding truth has so dominated inquiry methodologies since the renaissance that the word "research" has become synonymous with the "natural scientific method." Yet mathematics, the behavioral sciences and the humanities have their own methods, and within each group there are modifications and borrowings from others.

Librarianship is a very broad discipline that has characteristics in common with almost every other field. In fact, it is so broad and its parts are so closely related to other fields that it does not have a methodology of its own. The systems analyst, if he expects to address the problems of librarianship, must be able to work within these many methodologies. His traditional industrial engineering or natural science background is not enough. This section is a review of some of the more common research methodologies that the analyst must know well.

Let us begin with the assumption that research is the directed search for truth. By "directed" I mean that the investigator begins his inquiry with selected first principles, procedures and value judgment standards. He accepts the fact that the end result of his inquiry will be a function of his selection. In other words truth is not absolute. It is relative to the assumptions made.
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Churchman has recently written an excellent analysis of some classical inquiry methodologies. The discussion that follows borrows freely from his book. The deductive or axiomatic method, referred to by Churchman as the Leibnitzian method, is based on the belief that first principles are innate to the human mind. By identifying these principles we can build valid systems. Mathematics is the simplest example: the theoretician or working mathematician begins with the understanding that certain principles (he calls them axioms or postulates) are known without proof. For example, Euclid identified a set of postulates on which he built his geometry. The truth of the geometry is accepted because the postulates are "known" to be true and the rest of the system is consistent with them.

Yet there was a flaw in the system. In 1841 Lobachevski simply ignored Euclid's fifth postulate concerning parallel lines and substituted another. The result was a new geometry internally consistent but contradicting some Euclidian theorems. Mathematics eventually gave up the idea that absolute truth was possible and is now content to begin all inquiries with "If such and such is true then..."

The natural scientist is in a similar position. He begins with the belief that truth is to be found by observing the event world. He relies on the consensus of his colleagues to guarantee this truth. The scientist also has his limits. Many things do not lend themselves to observation, and contradictions abound.

The legal profession is a good example of a third method. Truth concerning a defendant's guilt is determined by the dichotomy established between the defense and prosecuting lawyers. Here all parties assume that truth (or a close approximation to it) will result from the fight between diametrically opposed positions. Churchman uses the philosophy of Hegel to develop this method.

Two methods not considered by Churchman, yet vital to librarianship, are the evolution and humanistic methods. Whereas the others begin with static assumptions, the evolutionist says that truth is a dynamic, continuously evolving entity. Hence truth is a function of time and absolute truth is beyond time. Teilhard de Chardin must be acknowledged for his work in this area.

The humanist also must be acknowledged. He believes that truth is a function of the individual. He would not deny contributions from others, but he would insist that each individual be free to place his own value judgments, or emphasis, on the factors he uses in his search for truth. The unspecifiable personal emotion is fundamental
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to the humanist. A recent work by Bernard Lonergan\(^6\) develops this approach and D. E. Berlyne\(^7\) has attempted to analyze the method.

"Participative observation," used so successfully by sociologists and cultural anthropologists, must also be mentioned because of its relevance to librarianship. Here the researcher assumes that he must become personally involved in the experiment itself if he is to find truth. Here the researcher observes as the scientist does, but he also becomes a part of the thing being observed so he can better evaluate its true meaning. Hopefully he has selected a perspective that will permit him to generalize on his observations.\(^8\)

Librarianship is a phenomenon which lends itself to investigation by all of these methods. It is also a holistic phenomenon, i.e., the parts of librarianship cannot be separated or divided into disjointed, noninfluencing parts without significantly influencing its truth value. This, of course, complicates the problem for the analyst. He must have a broad perspective and then select the methods that will give him, in his estimation, the closest approximation to truth. Indeed, the selection of methods is one of his most professional duties.

The time has come to recognize this broader interest and role of the systems analyst. He can no longer be considered as an engineer or natural scientist. Actually the transition can be quite simple if we focus attention on basic concepts and not on his tools and techniques. The new ALA Office for Research can also do much to bring this about. Its leaders need only to broaden their view of research beyond the scientific method.

RESEARCH AND DEVELOPMENT SPECTRUM

This inquiry process has another face. It is also a spectrum of activity beginning with a concept and progressing through research, development and implementation to the final operation. Specific problems can be placed along this spectrum. The tools, techniques, methods, and value judgments used by the analyst will be determined by the nature of the problem and its place on the spectrum. Let us, therefore, look a little deeper into the spectrum's characteristics.

Two initial observations should be made. The inquiry process is called a spectrum because there is a sequence or hierarchy to the process, and there are no clearcut boundaries or mileposts between major sections. The analyst always passes through all sections up to the place on the spectrum where the problem is to be found. He may unconsciously reject the earlier steps; however an element of accep-
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tance is always present. I will therefore describe each section as though the analyst were emphasizing that part.

When the initial problem is presented to the analyst, he searches through possible solutions and approaches to solutions. These are rarely well defined, just as the problem itself is rarely well defined. The initial step is to formally define the problem and possible solutions. This is the concept phase.

The next step is to determine feasibility. This is the principal objective of the research phase. Here the concern is not to find an efficient, best, or most acceptable solution. Rather the analyst wants to answer the question, "Is any solution possible, or which solutions are possible?" For example, the analyst may be designing the bibliographic citation that is to appear on a display terminal and determine the speed at which this citation is to be displayed on the screen. The solution to his problem is only possible within the physiological and psychological boundaries of humans as determined by experimental psychologists.

Sometimes feasibility is not so clearcut. It may be mathematically possible for a small college to use a $1 million book budget in one year, but in practice very little analysis would be needed to show that chaos would result if the school tried to spend it.

This is the phase that is commonly related to the theorist or scientist. He may use specifications, standards, and detailed data; however, these are only aids to help determine feasibility. In this phase, although the analyst has the final responsibility, he may call upon experts to provide information from which he makes value judgments and decisions.

The result of this feasibility effort is usually a redefinition of the problem and the elimination of impossible or poor solutions. The project then proceeds to the next phase with an increased probability of success.

The data and specifications from the research phase may or may not be carried over into the development phase. Here the objective is to take the possible solutions from the researcher and convert them into firm specifications or blueprints of the final solution. This is the area where the architect, engineer, and analyst are in almost total control. "Feasibility" is replaced by terms such as "acceptability" and "efficiency." Simulations, models and tests are common. Almost all the tools and techniques used by analysts today are used by them in this developmental phase.

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Developmental projects may require the services of many different kinds of people, yet it is here where the analyst is most likely to be in control. He has the overall vision of the program, and a sensitivity for the tools and techniques used. He is also an expert on the use of project control techniques such as PERT.

The output of this phase is not a finished product or operational system. Rather it is the specification to the person who will actually make the implementation. Again the probability of a successful finished product should be significantly enhanced if the analyst has done his job properly.

I do not see a significant role for the analyst in the implementation phase. The implementation of a solution, especially if it is a large design problem, requires the services of a special kind of person—one more like a building contractor than a designer or analyst.

The end of the spectrum is the steady state operation. Here the idea is to avoid change, avoid problems, and maintain stability. Again the analyst plays a role in this phase. It is he who designs and runs the management information subsystem that provides data for the operator's evaluation and control. The details of this activity will be discussed in the following section.

TOOLS AND TECHNIQUES

So far I have emphasized the analyst's intellectual working levels and decision-making activities. This section will return to the four basic activities of systems analysis—analysis, design, evaluation and control—and emphasize the tools and techniques to be used.

**Analysis**—Analysis of an existing operation usually begins with the development of a clear understanding of the function and purpose of the operation or problem. Function and purpose determine the tools, techniques and value judgments to be used in the analytic process.

The need for the “clear understanding” cannot be overemphasized. The analyst, management, and operations personnel must all be in agreement about both the nature of the operation itself and the nature of the analyst's assignment. Failure to give adequate attention to this factor frequently results in one of the analyst's worst sins—solving the wrong problem.

The next task is to determine the depth to which he is to perform the analysis. Is this a study to give management an overview, or is
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it to improve efficiency at the individual task level? Are there measurement tools available that will provide meaningful data at the level desired? These are the kinds of questions that help the analyst determine the proper level of depth.

Flow analysis itself usually begins with the identification and separation of the operation into meaningful parts. Again it is function, goals and depth that determine what is meaningful. These parts are then linked together (usually graphically) to give the analyst an accurate picture of the operation. This whole process is called flow charting. The completed flow chart is then examined for things such as dead ends, meaningless operations, circular routes, and repeated operations. Each step is checked to see why it exists and to determine if it can be eliminated without affecting the operation. The analyst must also be more than an efficiency expert. A step in an operation may be there only for psychological reasons, yet the operation would collapse without it.

This is also the time when each activity is identified according to its intellectual level. Here the recent ALA policy on education and manpower can be a valuable standard for library analysts. This document provided four levels of library tasks—professional, associate, technical, and clerical. A professional applies creativity to basic principles in the solution of problems. The associate is concerned with the creative application of established rules and techniques. The technician uses his decision-making powers to perform tasks in an efficient manner, and the clerk mechanically performs tasks that require no decision-making ability.

Some tasks lend themselves to quantification (e.g., the average number of keystrokes required to type a book order). The analyst must determine tasks for which quantification will be relevant, the method to be used to gather the data, the degree of accuracy needed, and the probability of biases.

The key word in quantification is “relevance.” The lure of numbers, their apparent authoritativeness, their definitiveness and their comparativeness tend to influence analysts to look to quantification whenever numbers can be gathered. This is one activity where a “devil's advocate” can usually temper an analyst's enthusiasm.

Flow charting and quantification are the two basic analytic tools. Two of the more important secondary tools are simulation and the use of standards. Machine specifications, regulations, laws, etc., also enter into the creation of an overall profile of an operation.
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Design—The synthesis of design operation is the inverse of analysis. Whereas the analysis activity is an attempt to determine how an operation now works, design is the attempt to create the best possible operation from both existing and new pieces. Whereas analysis tends to be a straightforward dissection activity with little feedback or interaction between parts, design is very much a cybernetic activity.

Design begins with the same steps as analysis—a clear understanding of what is to be designed. Did the analysis change the design criteria? Did the analysis solve the problem? Is the design feasible? Will the desired design give the desired results?

The analyst then searches his repertoire of tools, techniques and facts for an appropriate design process. He will select between a holistic and a modular design. He will choose between unique specifications and standards. Other factors such as cost, complexity, applicability, and maintenance will influence his decisions. As he selects design components, he tests them and fits them into parts of the overall system. Finally he has a working model or blueprint of the final operation. If he has done his work well, he will give the implementor detailed instructions for converting the blueprint into a smooth operation.

Overall design is the responsibility of the systems analyst. There may be specialists from other disciplines working on specific parts, but overall conceptualization, coordination and evaluation is the kind of work he has been trained to do. He sees the broad picture, can make value judgments and knows how to relate the parts to the whole.

Evaluation and Control—Of course evaluation and control occur as part of the analysis and design activities. These are also essential in the final operational phase. There is a need for management aids that will help keep the operation in a stable mode. The subsystem called MIS (Management Information System) brings together the tools, techniques and procedures that serve this function. (I am expanding on the terminology in common use today. Originally MIS referred to computer subsystems—hardware and software—used to gather data about large systems operations. The analyst designs MIS subsystems and plays a part in their operation.

I will begin with a description of an operation. Data about an operation are collected routinely and then fed to the processing operation where it is stored, synthesized, and compared with other data.
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It is then fed either directly to management where decisions are made, or to a data evaluation activity.

In the evaluation activity the data are evaluated with respect to four sets of constraints. These are the limits imposed by the operation itself (e.g., space or funds), past data, management decisions or constraints and technical limits (e.g., adequate statistical samples). The evaluated data normally go to management where decisions are made concerning the operation itself. Occasionally the data may be used for direct control. For example, no bills can be paid when funds have been depleted regardless of management's decisions.

The analyst plays two roles in this subsystem: he helps determine the data to be gathered and presented to management, and he is also part of the data evaluation activity.

I have presented the systems analyst as the library profession's problem solver. He has a repertoire of tools and techniques which he has inherited from engineering. His future will depend on a broadening of these tools and techniques into nonscientific applications. The analyst is very much an artist or creative professional. He works from the creative application of basis principles—not formulas.

References

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ADDITIONAL REFERENCES


Implementing the New System:  
Conversion, Training and Scheduling

HILLIS L. GRIFFIN

When all of the analysis has been done, and the studies have disclosed that it is time to implement a computer-based procedure to secure the desired objectives, several problems arise. One problem is that of building the data file which will form the basis for the new procedure. This may involve placing a substantial amount of information in machine-readable form, or of converting (and perhaps augmenting) an already existing machine-readable file. The staff must be trained to use the new system effectively and not to let it use them. Another problem is that of scheduling—how and when and where the jobs will be run, and how this schedule will mesh with the needs of the users of the system is another problem area. There is the story, for example, of the computer-based circulation system that was a winner in every way, except that the daily output always arrived a week late.

Conversion of the Information

The information upon which the new system is to operate must be assembled, put into machine-readable form, and validated. This may consist of translating the information in a single file of cards into machine-readable form, or of merging and selecting appropriate information from several manual files into the new data file. In any event, the information must somehow be transcribed (keyboarded or key-punched) into machine-readable form.

The source information for the new system may come from one or many files, and certain elements of information may be duplicated among them. The serial holdings of a library, for example, might be reflected in varying degrees of correctness in the binding file, a serials

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check-in file, a shelflist, the official catalog, or a line-dex display. One file might have better bibliographic information, and another might have better holdings information. Experience shows that there will be less than perfect agreement among the files on any item of information, and that ultimately a physical inventory of the holdings may be required simply to validate the information which is assembled from the manual files. The problem then becomes one of finding the easiest way to gather the information upon which to base the inventory, and to use as much of this information as possible in the final file.

The input equipment available to the user will strongly influence strategy in converting the data to machine-readable form. The best method will be that which provides the highest input rate with the greatest accuracy at the least cost, highest reliability, greatest ease of operation, and with a character-set which satisfies the job requirements in the most reasonable manner. Among the devices to consider are the keypunch, optical character recognition (OCR) equipment, intelligent and unintelligent terminals, typewriters which produce some machine-readable output (magnetic cards, magnetic tape, punched paper tape, punched cards), and others. Mark-sense and magnetic ink character recognition (MICR) are of such limited utility for bibliographic data that they need not be considered.

The keypunch is the most commonly available device. It produces punched cards which can be read by almost any computer. The IBM 029 printing keypunch has a substantial repertoire of special characters (punctuation) and, while it punches only upper-case letters directly, can rather easily represent both upper- and lower-case by use of a "shift code" to signify upper-case and nonstandard characters. In practice this limitation poses no great difficulty. Good design of the input format of the punched cards, together with a suitable computer program to read and reconstruct the input information and to provide validation listings, can furnish a fast input medium for the smallest installation at minimum cost. The keypunch is not a very sophisticated device, but it is completely independent of computer and telephone line difficulties. It functions with an extremely high degree of reliability and it can withstand a great deal of punishment.

OCR input is prepared by typing the information on ordinary paper using a typewriter whose type font, character and line spacing are compatible with the OCR input reader to be used. The typewriter is usually an IBM Selectric with an OCR typeball and proper line and character spacing. The user must be certain that the character-set to be
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used (including lower-case and special characters) is available on the typeball and can be recognized by the OCR reader. The OCR reader is connected to the computer and, like any other input medium, requires a computer program for its operation. OCR readers are not inexpensive, and are not commonly a part of a computer system. An advantage of OCR input is that keying errors are easily corrected, and that less training is required for typists to use the system than for other input devices. If the equipment is not already available, most libraries by themselves will not have enough work to justify the expense of adding OCR equipment to the computer system they will be using. Like the keypunch, the OCR input is read into the computer in a batch rather than an on-line mode. The keyboard devices are always usable regardless of any computer or telephone line problems.

The “unintelligent” terminal is generally a typewriter connected by a telephone line to a computer across the street or across the country. A typist types information on the typewriter and it is transmitted, line by line, to the computer, which stores the information on secondary storage (disc or tape) for later use. The terminal user can interact with the computer program to edit, validate, or search the information file. Various text-processing systems are available, among them ATS (Administrative Terminal System), Wilbur, Supercomp, and DataText, and many others are available on a service bureau basis, or on the user’s own computer. Such systems are very “typewriter-like” and require relatively little operator training for keying, although the operator must learn a repertoire of simple commands to operate the system and interact with the program. Input is not as fast as with the typewriter, and delays of 5 to 10 seconds per line may be encountered as system saturation occurs. Editing is somewhat clumsy because it is oriented to lines, rather than to sentences or paragraphs and it takes some time to type sentences back for editing purposes. Video terminals (a television tube display and associated keyboard) improve the visibility of data by displaying several lines at once, but many of these too have difficulties in accommodating changes which involve more than a single line of text. Telephone line or computer difficulties make the terminal unusable until they are resolved. Costs of these systems typically involve rental of the terminal, equipment for attaching the device to the telephone line, telephone line charges while the system is active, costs for special telephone lines (if the ordinary lines are too “noisy” for normal operation), computer time charges for time hooked up to the system, and charges for data storage.

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The "intelligent" terminal is typically a video terminal with a small computer inside. It may operate under an editing program similar to ATS, or under a user-provided editing program which is tailored to the application. The data may be written on a cassette of magnetic tape (like those used on small cassette recorders), or the terminal may interact with a large computer much as does the "unintelligent" terminal. If the information is gathered on cassettes, the terminal is completely independent of the large computer, and is quite portable. It can, however, communicate with the large computer via telephone line to transfer the collected information from the cassettes to some other storage medium associated with the large machine. In this case the terminal requires only computer and telephone line time sufficient to transfer the accumulated information, which is much less than the time taken to accumulate it. This leads to some saving in telephone line and computer time charges and gives a greater degree of independence from the large system as well. The video terminal has the inherent capability of rapid response since there are no moving parts required to display characters, and it can normally display an entire bibliographic entry in a single screen—a benefit for validation. Unfortunately, there are presently only a few video terminals which are both reasonably priced and satisfactory for text processing. These are adequate, however, and new and better equipment is rapidly being made available.

A more powerful extension of the intelligent terminal is the combination of an unintelligent video terminal (or several of them) with a minicomputer, disc storage device, tape drive, line printer, and appropriate telephone line adaptors. Such a system can accumulate data onto normal 7- or 9-track magnetic tapes or onto cassettes or disc for later transfer to 7- or 9-track tape, can send or receive data across high-speed telephone lines, and can print validation (or other listings) on a medium-speed printer, as can many intelligent animals. Such a system can handle several terminals simultaneously, and it is in this situation that it is most economical. This is the basis of the commercial key-to-tape and key-to-disc systems which are popular replacements for keypunch systems. Unfortunately, most of the commercial key-to-tape or key-to-disc systems have input devices which do not display the results of the input to the operator (much like a typewriter which does not print what has been typed).

The typewriter which produces some machine-readable output should also be considered. There are several devices of this kind, each producing a different product. The IBM MT/ST (magnetic tape Se-
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lectric typewriter) produces a magnetic tape cassette which can be converted by appropriate devices to the usual magnetic computer tape or used directly as computer input with the MT/ST cassette reader that attaches directly to an IBM system 360/370 computer. The reader is not priced for the low volume user, however. Another device for off-line conversion to magnetic computer tape is the Digi-Data converter. Both the Wang Laboratories and Texas Instruments Co. have announced keyboard devices which produce hard copy and cassette tapes. The Wang typewriter is rather like the MT/ST, with editing capabilities, plus the ability to transmit over telephone lines. The Texas Instruments machine produces copy on a special paper with a thermal (rather than an impact) printer. It is priced considerably lower than almost any other comparable device. Also available is the IBM MC/ST (magnetic card Selectric typewriter) which records data on the edge of fanfold cards with a magnetic coating. It also has an associated data-transmission device.

Also available are punched paper tape typewriters, which record each key-stroke on punched paper tape. They require a device either to convert the punched paper tape to punched cards or magnetic tape off-line, or to read the punched paper tape into the computer. While punched paper tape readers are often found on very small computers, these computers generally cannot produce magnetic tape or punched card output. The larger computer systems seldom have a punched paper tape reader as an associated input device. Furthermore, punched paper tape is difficult to correct. So, considering the various difficulties in using it and the cost of input devices to get the information into the computer, there are easier, cheaper, and more reliable ways than punched paper tape to do the job.

Which one should be selected? The choice is often made simply by the equipment which is locally available. If the computer available does not have OCR equipment, then one will probably not be able to justify its addition to the system solely for the library. The computer available also may not be of a type capable of supporting on-line terminals. If there is no money for equipment, perhaps time can be stolen on a locally available keypunch, and if there is only a little money, renting a keypunch is an option. With access to a data entry system via telephone line, another alternative is open. At some point, line and connect-time charges will make an intelligent terminal very attractive. Another alternative is to have the job done by a service bureau of some sort. This imposes a new set of decisions to be discussed later.
Next comes the task of putting the input information in some form which is usable for the keyboarding operation. The traditional method is the worksheet. This is a sheet, filled with squares, onto which the data is manually transcribed in block letters so that the typist or keyboard operator can then key the information. Another expedient is to type worksheets which can be used by the input clerk for data entry.

One advantage of doing the conversion job within the library is the familiarity the library staff has with the information. Ever since the acceptance of the typewriter as a piece of library equipment, clerks have been transcribing catalog cards on the typewriter from hand-written copy (written on the back of a proofsheet), or a "revised" proofsheet or LC cards. Through some miracle the clerk is able to transcribe this information onto a typed card in the proper format. But somehow, when people begin to deal with computer input, they suddenly become more formal. If one considers that keying information is infinitely faster than writing it in squares in block letters with a hard lead pencil, then it is reasonable to refrain from filling in worksheets by hand. If they must be typed, why not just key the information into whatever is to be used for computer input, rather than prepare a worksheet? It is faster and more efficient, and helps to reduce the cost of labor for conversion. Since labor will be the major cost in conversion of a system, every possible way should be sought to conserve labor.

One of the traditional reasons for worksheets is to allow the key-punch operator to key-verify the information that has been punched. This process consists of re-keying the information on a verifier machine to see that the holes in the card agree with the characters on the worksheet. This involves two keying steps. Key verification is certainly the best way to validate typical accounting data—account numbers, part numbers, quantities, hours worked—all difficult to proofread visually. But bibliographic data can be proofread more rapidly than it can be re-keyed.

The conversion then might well be done within the library, using library staff to do the keying, and using raw data directly from the library records, rather than worksheets. Given a good input format (on the keypunch) or a "fill-in" interrogative program (on a terminal system) the clerk should be able to enter the information rapidly, even using more than one file to supply the required information. After a
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short time, the operator will be able to proceed more rapidly without the prompting of the “fill-in” program on the terminal system.

The computer can be of considerable assistance in proofreading. It can place the input in sequence, print a prooflist which will display the information in a form which makes it easy to use, and perhaps also in the input format as well. But the program can do much more. In the case of bibliographic information, for example, it can detect many of the mechanical errors in the input and let the proofreader check for errors in spelling, etc. Mechanical errors include such things as a missing call number, an all numeric LC classification number or Cutter number, a mixed alphanumeric Dewey classification number, a publication date later than this year, or earlier than, for example, 1900 (or whatever is chosen), the absence of the main entry or the title, or the appearance of two titles (one of which probably should have been the added title), etc., there are many things that the program can look for and identify. The proofreading program should make things easy for the proofreader, because this will increase the accuracy of the proofreading task.

If manual files are at hopeless odds, what can be done? One method is to convert the best file to machine-readable form, and use a computer-produced worklist to note corrections, additions and changes. The worklist can be split into sections so that several people can work simultaneously on different parts of the alphabet, and with different files at different places. The revised worklist forms an excellent basis for entering the accumulated changes and corrections, and assures that they will not be lost or duplicated. The wrong way to do this is to take time to type a work file on 3 by 5 cards and use this file to resolve problems. The keystrokes could have been better invested preparing the actual input to the machine-readable system.

It might appear that the easy way out of the travail of file conversion would be to farm the job out to some enterprising and utterly reliable contractor who would, by some magic, and without removing records from the library, effect the file conversion. There are, for example, contractors who will microfilm your input and send the film overseas, where it will be keyed and returned on magnetic tape. Costs are generally much lower than for domestic labor, but turnaround time must be allowed.

There are also domestic service bureaus which will accept conversion work to be done on keypunch, terminal, or OCR devices. There is
also the campus data processing center which may agree to keyboard your records on a "time available" basis. This usually turns into a bitter and frustrating experience for all concerned.

All of these schemes assume that the data is in a format which will allow it to be keyed as it stands. If it is not, then the data will have to be transcribed to worksheets which can be used by the keyboard operators. If the library has to do the transcription, then it might be better to hire and train some temporary help, or begin training the affected staff to do their own keyboarding. Since nobody is as interested in a project as those it directly affects, the best way to guarantee its success is to give it close and sympathetic supervision by people who are interested in and responsible for its success, and who will have to live with it later.

STAFF TRAINING

If the new system is to work properly, the staff must acquire new skills to learn how to use it. The conversion process may require training of staff even before the final system is operational, but this gives them a good opportunity to participate in the development and growth of the system, and for their skills to grow with it. The conversion period is generally a more relaxed time so that learning can proceed without undue pressure.

Those who are directly involved in entering information into the system will need to learn how to operate the keypunches, or the terminals. Keypunch instruction using programmed courses commercially available on magnetic tape has been very successful. A course of instruction covering 2½ days turns out excellent keypunchers. Terminal systems often have a tutorial mode to indoctrinate new users. In any system the machines are the easy part—the knowledge of the library and its ways comes harder. Mastery of the mechanical procedures will enable the operator to give full attention to the protocol of entering information—the format, the rules, the procedures. The best system will be one which conserves labor, maximizes speed of throughput and minimizes errors—that is, one which puts most of the burdens on the computer rather than on the input operator.

The people who work directly with the system need to know other things about it as well. They should have some idea of its goals, how it does its job, and their part in all of this. And, finally, they should actually watch the computer at work. No matter how well the process of catalog card production on the computer is described—the speed of in-
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put, of sorting, of alphabetizing the records (the reverse of the manual procedure) and then of printing—nothing is quite as awe-provoking or as ultimately descriptive as seeing the computer do it.

The new users also need to know how to recognize problems and solve them. Any new system has problems; this should be admitted to the staff along with the information that they are part of the solution. Key punching errors that are not corrected threaten the reliability of the system. So do programming errors, and both should be corrected without delay. The people actually using the system will suggest additions, revisions, or improvements, and they should be heard and heeded. If the problems are not resolved the users suffer, the system is not effective, and the library is the ultimate loser.

Training in programming and systems analysis should not be a library concern. Programming classes are offered on many campuses. The problem will be in applying the language, usually presented in a mathematical (FORTRAN, PL/1) or business (COBOL) context, or as an entity in itself (assembly language) to the library and its very diverse needs. It is unfortunate but true that the best environment for library programming is within the library by programmer-analysts who have had training and appropriate experiences as librarians. They know why libraries do the peculiar things they do, and they have some interest in doing things better. If they are on the library staff, they are visible and face the prospect of living with satisfied or dissatisfied users—a good incentive to make the system work well.

The training program is probably best operated by the library itself. It will be a continuing responsibility because of personnel changes and systems changes. To direct the training program, oversee the conversion and handle day-to-day problems, an articulate, understanding person who knows how to use the equipment, understands the system, and can communicate this knowledge to the library staff in their own language will be invaluable.

Levels of training are related to the needs of the job, and the skills of those selected for training. Experienced keypunch operators will often need to learn new techniques to cope with the large amount of freeform alphabetic information. Typists will find out very quickly that you do not backspace and "x-out" mistakes on the keypunch. Given a choice, the best candidates will be those from the library with adequate keyboard skills who are alert and able to proceed independently.
SCHEDULING

The library will need some appropriate guarantees that its jobs will be run on the computer in a scheduled and timely manner. In the case of an on-line system this also means that the appropriate library files will have to be on-line (and consuming some substantial part of the system resources) when they are needed. The on-line circulation system is a case in point; it cannot be on-line only on alternate Tuesdays from 4 to 5 in the afternoon. Batch operations also need to operate on schedule if they are to be reliable and useful.

Most libraries will find it satisfactory to have their batch processing accomplished at night or on weekends, often at less cost. In this way they can fully utilize normal working hours to prepare input to the system, making it current to the close of the day. The output, run that night and returned the next morning, will be current. But it must come back the next morning if people are depending on it to do their jobs.

Long computer runs may be scheduled for an otherwise slack period in the computer time schedule. The work load in a business-oriented computer center is often cyclic and there are also cycles in a scientific computer center. Such scheduling requires planning and coordination with the computer center, but will assure prompt attention to these jobs.

This work was performed under the auspices of the United States Atomic Energy Commission.
Large Scale Library Systems

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At a time when libraries are adopting systems analysis as an integral part of their management structure, systems analysts are voicing grave concern about their ability to deliver the kinds of systems libraries need. This ambivalence is not due to any loss of confidence in the power and precision of their methods, nor in the general usefulness of these methods to improve library operations. It is more a concern with a basic dichotomy between mechanical technique and human behavior. Systems are for people, and the systems impulse is towards a totality of involvement which encompasses all factors, including the human ones. Yet, the formal determinism of systems analysis as it is practiced today usually precludes human values, and tends to build systems which replace, compete with, or use men.

In the jargon of Marshall McLuhan, systems analysis is a hot medium which needs human participation to complete the message. How to do this is the major concern of a new breed of systems analysts who refer to their work as “large scale systems.” In the search for “libraries of the future,” they see how earlier theorists precipitated considerable hostility in library circles by their seemingly ruthless mathematical chauvinism. Today, there is more willingness to concede the field to the nonquantifiable aspects of systems design, and more concern that the wholesale use of deterministic approaches will create technical monstrosities.

THE MISUSE OF NUMBERS IN DECISION-MAKING

Roy, in his book The Administrative Process, observes how numbers tend to dominate managerial decision-making. They push aside intangible factors which can not be quantified, and they assume an aura of accuracy that can not be justified. Ideally, Roy says, “decisions should be made by: (1) maximizing the available precise information; (2) ac-
according to the quantitative elements only that degree of confidence merited by the numbers; (3) giving due and proper weight to all the other intangible non-quantifiable factors. Roy says, is that steps (2) and (3) are ignored or abused by: "(2) according to all of the numbers complete and total confidence; (3) allowing the numbers to set aside, negate, and dominate the intangible elements, even when these are of overriding importance." Numbers used in this way obviously are detrimental to sound decision-making.

Roy is clear, however, in his advocacy of the use of numbers for making decisions. For him, "the more numbers there are and the more accurate they are the better." His concern about the misuse of numbers is shared widely by analysts, managers, and laymen alike, who are pre-occupied with the societal and environmental impact of technology. This is not because of any fundamental change in belief in the technical power or logical validity of systems science. Rather, it is because of this power that there is such concern about how it will be used.

Science has provided powerful methods for solving operational problems which can be formulated as analogs of real human situations. By a detailed enumeration of all quantifiable factors, computers can be programmed to simulate decision-making processes and behave in an adaptive manner. In this way the problems associated with small scale situations sometimes can be resolved with a degree of scientific certainty that is out of proportion to the assumptions and conditions which made the formulation and solution possible in the first place. As this approach is extended to encompass situations of much larger scale and complexity, the analytic techniques begin to falter and the role of subjective judgment becomes more obvious in dealing with real man/technology situations.

In real man/technology situations, man must always be the dominant element. In the long run, man's capacity for learning and growth gives him the edge, while any given technological formulation becomes obsolete and eventually fails. In the short run, however, technology may dominate man and force him into self-destructive behavioral patterns. The ability to design man/technology systems that allow both man and technology to operate at their fullest potential is no mean feat. Obviously, to the extent that design concentrates on technical development only and on ways to coerce men into compliance with such developments, there is little chance of success. Today, more attention is being given to the study of the technical problems of human systems.
than to the human problems of technology. This is the large scale systems approach.

**MATHEMATICAL LITERACY IN LIBRARIES**

As libraries make more use of mathematical models and computers in their normal operations, they must necessarily change the level of knowledge about these techniques that is expected of the professional members of the organization. This is not to say that every librarian will eventually need extensive formal training in mathematics and computer science. It does mean that every librarian affected by the new methods needs to be made aware of the extent and source of this influence on his work. It is not possible to keep such knowledge confined to a small group of staff analysts.

All persons whose authority and responsibilities could be enhanced or compromised by the development of new systems within the organization must be given access to the planning processes governing these developments. This will necessitate an increase in their conversational literacy about numerical methods. Experience at Purdue University has shown that it is not difficult to achieve such awareness in a library staff if they are given a meaningful and regular opportunity to develop and practice such skills.

In the Purdue experiment, the staff met weekly with administrators and analysts in a series of presentations and critiques of systems analysis and operations research studies of library problems. Within a relatively short time, there was little difficulty in achieving meaningful open dialogue about fairly sophisticated systems concepts. The depth to which any one technique could be explored varied considerably, to be sure; but the significance of these techniques in a particular application could be freely explored at great length to the edification of all participants.

Because the top administrators of the organization attended these meetings regularly, there was little question about the importance of these discussions. It provided an opportunity for all persons to discuss common problems in a free and professional manner. The often oblique and sometimes naive arguments of the analysts had the beneficial effect of making room for other points of view. That this did not always lead to a convergence of arguments was more a measure of the complexity of the problems than the intransigence of their positions.

Mathematical and computer methods did not become a major stumbling block in these deliberations. In fact, there was little concern with
limiting the range of sophisticated techniques that might be discussed. Always these were introduced from an applied or ad hoc viewpoint. Criticism was focused on the insights gained from the technique about the library problems under study, and not on the technique itself. The presence of other analysts and the side discussions among them gave sufficient attention to purely technical questions.

While this approach to systems analysis is not easy to start and maintain, there is good reason to believe it is absolutely essential to extensive system development in a library organization. Historically, it is a logical extension of the team concept in early operations research and systems analysis studies. This approach was justified initially by the need for interdisciplinary approaches and for the close involvement of analytic and operational viewpoints in developing promising alternatives to urgent problems. With the development of very large projects with clear technical missions—such as exploration of the moon—hierarchical staffs of systems specialists could be justified. Highly technical organizations can make good use of systems specialists in a selective, consultive manner; but, as systems methods are applied to situations with a high "human content," participative planning must be deliberately cultivated as a crucial element in systems development for the long run.

PARTICIPATIVE PLANNING IN SYSTEMS STUDIES

Ackoff points out that the benefits of systems planning are not derived by "following a plan" but by engaging directly in the planning process itself as an ongoing activity. "Effective planning cannot be done to or for an organization; it must be done by it," Ackoff says. "Therefore, the role of the professional planner is not to plan, but to provide everyone who can be affected by planning with an opportunity to participate in it, and to provide those engaged in it with information, instructions, questions, and answers that enable them to plan better than professional planners can alone."2

Because of the complexity in maintaining an effective planning activity, mathematical models and computer methods must be used extensively as a way of collecting, processing, storing, and retrieving the information needed for planning. These techniques can be helpful in the organization of the planning process itself which must be continuously updated, coordinated, interactive, integrated, and experimental. Computer-based information processing is the only feasible approach to the development of truly adaptive general purpose organizations of large
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size. As Bernal pointed out some years ago, effective communication takes the place of administration in organizations where persons act with a great deal of professional freedom and integrity. As an academic and theoretical question, the applicability of mathematical models to library operations is still highly debatable; i.e., there is a very limited body of organized scientific opinion to support the argument that certain library activities follow mathematical "laws." The number of people who are able to devote much of their time to such discoveries are very few, and probably will remain so as support for pure research dwindles. Basic research of this kind should be encouraged within the library profession, but it is not necessary for libraries to await such developments before engaging in serious systems development.

In the practical work of systems design, the goal is to find better methods for delivering library services—not finding the one best method. Optimization to the systems scientist has a very precise mathematical meaning, while to the systems practitioner it represents a general direction to aim for. It is more like a point of view. The validity of systems models in practical work is the degree of belief they muster in persons of authority, and not something to be demonstrated in a refereed journal. This is not to say that theory and practice are to be kept in airtight compartments, but that there should be recognition of the important difference in their viewpoint.

Operations research models used to process operational information for organizational purposes takes on a status similar to that of an accounting system in a business. Anyone familiar with accounting systems knows how inexact they are. In fact, accountancy is more a study of proper interpretations and the resolution of system conflicts than it is the precise mechanics of bookkeeping. The value of such information processing systems rests in their ability to give some limited sense of order to a highly complex situation by engaging the conditional belief of the persons involved.

SMALL AND LARGE SCALE SYSTEMS

Libraries make use of a considerable amount of financial resources. There is good reason to expect libraries to make as good an accounting of their use of these funds as is demanded of other institutions in society, and there is reason to believe this is not being done. Mathematical modeling and information systems development in this area of application can be of considerable merit. Libraries also use valuable physical
facilities and engage in extensive material handling operations. Such operations lend themselves naturally to technical treatment. The problems associated with physical systems can be readily formulated in a mathematical manner and solved in a systematic way. Information processing for clerical purposes is another aspect of library operations that can be readily systematized, providing that the time and energy is made available. A considerable amount of the human work done in libraries, including that of professionals, can be measured and organized in a systematic way. Opportunities such as these for starting library systems studies are of considerable practical value and do not present great technical bottlenecks calling for basic research. The amount of mathematical sophistication one could employ in such work is virtually unlimited, but whether it is worth it or not is questionable.

The kinds of applications referred to above properly can be called "small scale systems analysis." They are small because the work can be easily confined to limited areas of study, using well-tested methods, measuring a limited number of variables, employing self-evident measures of effectiveness, and causing little radical change to existing organizational structures. Studies which do not have these properties fall into a category called "large scale systems," for want of a better term. Here, too, mathematical sophistication is not the necessary ingredient, although it will not hurt to have some present. There is a class of mathematical programming problems called "large scale" and there is some overlap in significance. However, what is meant by the term in the more general sense derives from the orientation towards the structuring of human behavior in complex societal situations.

Libraries qualify as large scale systems on three major counts: scale, continuity, and complexity. Because of the impossibility of isolating any single modern library from the national and international environment in which it functions, the scale of any major innovation in library procedures is immediately very large. For example, the study of purchasing, classification, or reference operations quickly brings the analyst into confrontation with system constraints well beyond his control. The whole economic viability of the library system depends on such interactions among libraries.

Continuity is a fundamental condition of life in a library. Any significant tampering with storage and retrieval systems leads to problems of continuity with previous methods locally and elsewhere. Provision for future activities is an essential consideration in library systems develop-
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ment. Services are designed to accommodate all possible future contingencies of library use to the extent possible.

LIBRARY COMPLEXITY

Complexity is natural to the library environment because of its primary mission to meet basic human intellectual needs. What could be more complex? Licklider calls the library a “procognitive system.” Wilson points out that such systems are theoretically impossible to automate totally since they are concerned with all possible human uses of information. Because of the essentially political nature of the human need for information, Wilson believes the problems of library systems design necessarily transcend technical and economic considerations.

Churchman argues along lines similar to those of Wilson when he puts down the presumption that library effectiveness could ever be measured in quantitative ways. He says the true benefit of such systems must be in terms of the meaning of information for the system users in a moral and aesthetic sense. To the small scale systems analyst such arguments create a paralyzing dilemma as he seeks some kind of formal validation for his models. Churchman’s purpose here is not to dissuade libraries from engaging in systems analysis. On the contrary, he encourages it, but insists on recognition of the severe handicap under which it must be pursued.

The recognition of libraries as large scale systems helps to clarify the role of systems analysis in such organizations. First, by recognizing the limitations of conventional systems studies from the outset, it is possible to be much more deliberate and efficient in such work. The level of technical sophistication can be kept more in line with the requirements of the study and the capabilities of the organization. The inherent hostility generated by such studies within an organization can be ameliorated by establishing firmer expectations and clearer limitations on the jurisdiction of such studies.

The second major benefit to be derived from the distinction between large and small scale systems is the understanding that large scale systems are “people systems.” System development of this kind depends on the capacity of people to negotiate mutually beneficial agreements so as to engage in and to sustain creative and innovative efforts that affect everyone. System development becomes synonymous with human development as a continuous, interactive process of coordinated adaptation to a changing environment. While the full scientific valida-
tion of such developments will be a long time in coming, the principles for engaging in such an enterprise are not that difficult to come by. See for example, Maslow's description of the "slow revolution."s

Technique has an important place in large scale systems, but it is not to create the machine to end human work or the push-button for an easy future. Ackoff notes that: "We waste too much time trying to forecast the future. The future depends more on what we do between now and then than it does on what has happened up to now. The thing to do with the future is not to forecast it, but to create it."2

MODELING IN LARGE SCALE SYSTEMS

Mathematical models are needed in both large and small scale systems work to process factual information in an efficient manner. The formal, scientific rules remain the same for verifying the internal accuracy of such models and for manipulating them to show the kinds of relationships and properties they infer. What is most different about models in the large scale systems context is the emphasis on the limitations of models as "canned" substitutes for human activities, and on the value of the modeling process as a creative human activity.

Solberg, in a recent paper, offers the following principles for large scale systems modeling:

1. A model should not be taken too literally.
   The more elaborate and sophisticated a model is the less easy it is to be objective in evaluating its usefulness relative to its original intended purpose.
2. Do not oversell any particular model.
   "When a model is sold as a 'package of truth' rather than a 'package of plausible assumptions that lead to useful conclusions,' and it later turns out that the implied real world actions were somehow in error, we may suffer a backlash out of proportion to the error made."
3. The deduction phase of modeling should be rigorous.
   "If model deduction has not been carried out rigorously, we cannot distinguish between external errors in formulation and internal errors in logic."
4. A model should not be pressed beyond the limits of its capability.
   An example is the use of forecasting models to predict future events from irrelevant data.
5. A model should not be criticized for failing to do what it was never intended to do.
   "This principle is really a corollary to the preceding one. It is worth
starting separately because it is easy to attribute to someone else, one's own motives."

6. **Models should be validated.**

Validation can be carried too far. One may reach a point where an enormous effort is required to increase one's confidence about the model just a little bit. Depending upon how important the model is, one may be wiser to tolerate a lower confidence level.

7. **Do not build a complicated model when a simple one will do.**

(Occam's Razor revisited.) It is common practice in mathematical modeling to begin by introducing as many assumptions as are needed to make the mathematics tractable, and then begin to "enrich" the model by weakening the assumptions until the mathematics is no longer tractable. Such a procedure will produce the "strongest" model, but such strength has little to do with its usefulness. "This principle of building the strongest model one can is," in Solberg's opinion, "a useful principle in the training of model building, as a kind of academic exercise to keep that mental muscle strong," but he does not believe it should be a guiding principle in the actual practice of model construction. "To put the same point in the form of an analogy, lifting barbells may be a good thing to do insofar as it increases one's capacity to do useful work, but it is not in itself useful work and should not be thought of as such either by participants or observers."

8. **The medium of expression for a model should be selected according to its intended purpose.**

Models should not be shaped to preselected solution techniques. Rather the problem should shape the model and the techniques.

9. **Some of the primary benefits of modeling are associated with the process of developing the model.**

"Generally speaking, a model is never as useful to anyone else as it is to those who develop it. The model itself cannot contain the full knowledge and understanding of the real system that the builder must acquire in order to successfully model it, and there is no practical way to communicate this knowledge and understanding adequately."

Solberg's principles focus on the shortcomings of mathematical models as a medium of communication in the design and development of large scale operational systems. Among analysts the model is the message. It is the accepted form for conveying information about new developments in the field. But, more than that, it is a form of creative
expression of a particular kind and has its own rules of acceptance and qualities of elegance. Such forms of expression require some training on the part of those who would appreciate them.

SYSTEMS DEVELOPMENT IN THE FUTURE

The role of aesthetics in system modeling can be more easily seen in the use of computer programs. Programs are a more prosaic form of communication. Since they are written for robots, they are pure action statements that either work or fail. However, there is much opportunity for exhibiting human skills in the efficiency with which programs fulfill their appointed tasks. The user of computer outputs may have little appreciation for the elegance of the program used. Even if the patron is paying the bill for computer time, he has good reason to examine the trade-off in programming cost versus operating costs. Tests often fail to justify elegant programming. This kind of skill is important when it is necessary to make a computer operate at its maximum capability.

In a similar vein, as one attempts to model systems with attributes that seriously challenge the relevance of mathematical arguments, the ingenuity of the modeler becomes the crucial element. Linvill, in describing the changes in modeling required by large scale systems, notes that it is unlikely that the analyst can continue to rely on detailed quantitative analysis. "The future success of the system modeler," he says, "is probably more concerned with his ability to translate the concepts of modeling to the nonphysical situations which are becoming increasingly important in large scale systems analysis than with his ability simply to manipulate purely quantitative models."

Linvill identifies four types of models that are of greatest importance in societal systems: (1) large scale mathematical programs for handling a large number of interacting variables in a simultaneous manner, (2) dynamic models which focus on system stability, rates of change and acceleration factors, (3) stochastic models which allow for uncertainties and risk taking in decision processes, and (4) logical models which can be used to structure multiple and hierarchical objectives and to lay out scheduling patterns.

The key idea in Linvill's paper is that "the center of gravity of activity in systems analysis has moved from mechanistic systems to humanistic systems; and, accordingly, there is an increasingly strong demand for including behavioral and social sciences as a background for the
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analytical modeling work, as well as the technological and quantitative concepts that have been applied up to now.\textsuperscript{11}

Linvill also stated:

Humanistic systems are living organisms and must be treated in a way fundamentally different from mechanistic systems. The system analyst must deal with human beings. He must develop agreements instead of controls, he must discover objectives rather than to set them, he must discover constraints and utilize freedom to an unusual degree. There must be a vital interactive humanity involved in humanistic system design. To be most useful these attributes must be added while the familiar characteristics of the mechanistic system analyst are not lost.\textsuperscript{11}

These developments in the field of large scale systems are most important for libraries and information systems. Just as large libraries were important arenas for the development of operations research concepts at several universities during the 1950s and 1960s, there is now an opportunity for them to join in the perfection of these new approaches to societal problems. Because of their rich humanistic content and their commitment to intellectual service, libraries should stand to gain even more from these new developments than they have from past involvement in systems analysis efforts.

References

9. Solberg, James J. “Principles of Systems Modeling.” In International Sym-
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11. Ibid., p. 84.
Analysis of Costs and Performance

RODERICK M. DUCHESNE

Nearly all systems analysis work is directed in greater or lesser part toward achieving improvement in system performance relative to system cost. The vast majority of studies, however, either treat cost-effectiveness in a somewhat subjective way or relate to specific library processes and subsystems. The purpose of this chapter is to outline the most practical approach for analyzing costs and performance in a manner comprehending all the services and processes of a library or group of libraries. A library management information system is proposed which provides budget, cost and performance data for planning and control purposes in addition to conventional financial and statistical statements. This approach is practical not only in the sense that it is oriented to practical library management problems and goals, but also in the sense that it is designed to be a cost-effective aid to library management. The emphasis is on producing essential data at minimum cost.

A related modeling approach is briefly described. For theoretical discussion of cost-effectiveness analysis and cost-benefit analysis and their application in other fields see the Additional References. The paper by Walsh provides an excellent summary of the formidable theoretical and practical problems in the cost-benefit area. Closer to the library field are discussions by Lancaster, Orr and Wessel.

A Library Management Information System

Hayes and Becker argued cogently for the adoption of cost accounting by libraries: "In summary, a cost accounting system is continuing rather than intermittent; it is concerned with the total library and not with some detailed aspect of it; and it ties together costs with effectiveness rather than being concerned with simply one or the other. Cost


APRIL, 1973
accounting is a management tool of primary value to the librarian in his day-to-day control of his own library."

Hayes and Becker provide a brief sketch of a cost accounting system with a list of possible report outputs, tentative cost reporting forms and illustrative unit costs. Operation of the system represents a cost in itself: "It is relatively easy to accumulate statistics or to control budgets; it requires a recording system to tie the two together. As a result, a cost accounting system represents a cost in itself. Its costs must be weighed against values received." 7

Hayes and Becker discuss rather than describe a system and it is necessary to refer elsewhere for a clearer idea of the main outputs of such a system and for background statistical 9 and accounting works. Concerning accounting, Horngren 9 is both thorough and readable. Concerning budget statements, Brutcher 10 and Raffel and Shishko 11 are most helpful; the following account synthesizes and attempts to extend the approaches in the literature on library management information and accounting.

PURPOSE

As Horngren puts it: "Budgets are designed to carry out a variety of functions: planning, evaluating performance, coordinating activities, implementing plans, communicating, motivating, and authorizing actions. . . . When administered wisely, budgets (a) compel management planning, (b) provide definite expectations that are the best framework for judging subsequent performance, and (c) promote communication and coordination among the various segments of the business." 12

There is a vast difference between a management information system and the mere reporting of miscellaneous retrospective statistics such as those of United Kingdom university 13 and public libraries 14 although the system must also produce such statistics as required. Budgets are a planning tool recording expected workload, output and costs. Performance and cost are regularly compared with projected budget figures and corrective action is taken as necessary on any variances. The process may be continuous: continuous budgets are increasingly used, whereby a twelve-month forecast is always available by adding a month or quarter in the future as the month or quarter just ended is dropped. Concerning process budgets, it is highly desirable that the budgetary process be participatory, i.e., that section and department heads responsible for expenditure participate in preparing the budget projection. This draws them directly into the planning process and in-
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sures their interest in and commitment to the budgets for their section or department.

SYSTEM OUTLINE

The minimum inputs for a full system are:

1. Budget and actual figures of expenditure for capital items, indirect revenue expenditure, and direct expenditure by cost center.
2. Process and program parameters specifying the proportions of department/section costs attributable to each process and program. These parameters may be established by periodic surveys.
3. Basic performance data for the process budget and external returns.

This data is coded, punched and input to a data processing system. Given adequately coded data and appropriate computer programs virtually any analysis can be produced; tables 1-5 illustrate some basic analyses. The main operating costs of the system are in the planning process to set the budgets, the recording and input of the data, and computer process time. Data recording and input is kept to a minimum by use of intermittent surveys for process and program analysis; the costly alternative is direct recording of each person’s activity all the time.

Tables 1-3 illustrate analyses designed for budgetary control of total library costs and output. The budgets represent definite expectations about the future, against which present costs and output statistics are compared. While these are summary analyses, they would in practice be built up from and supported by departmental analyses involving departmental managers in the budgetary process.

Table 5 is an illustrative process budget statement derived from the basic data in tables 1-3. The process budget, as its name implies, shows the costs and output indicators of the main library processes. It readily shows movements in the cost-performance ratios of the main library processes and is a powerful tool for monitoring costs and performance.

Some points should be noted concerning the process budget statement. Its “processes” are not synonymous with departments even though the names may be the same—order, catalog, reference, etc. Reference process costs include reference work done by all departments, not merely the reference department; for instance, members of the catalog department may undertake reference work and this cost is shown against the reference process and not against cataloging. Direct labor, material and expense are costs booked directly against the various pro-
cesses. Indirect costs are those which are not booked directly against processes and is a powerful tool for monitoring costs and performance. costs and their mode of apportionment. The document exposure unit included in the process budget is described in detail by Hamburg.15 Survey techniques are used to quantify the average reading time per loan, per photocopy, per library visit; these figures are then applied to the number of loans, photocopies and reader visits to obtain total reading or “exposure” hours. If the number of visits to the library is in doubt, survey techniques can be used to determine the average number of visits per reader per time period.

Table 6 shows an illustrative program budget statement designed to assist in planning the proportion of total resources to be devoted to the library’s main objectives or “programs” and to monitor actual expenditure against budget. The programs in the table are those identified by Raffel and Shishko16 for the M.I.T. libraries; other libraries such as public and national libraries will identify quite different programs. There are, however, differences between the approach advocated and that proposed by Raffel and Shishko. First, the program budget should not exist in isolation and should be integrated into a scheme of interlinking budgets—as tables 1-6. This necessitates imposing a uniform mode of analysis by cost element—labor, etc.—and process. Second, the power of the program budget as a management tool is greatly enhanced by including both budget and actual figures.

SYSTEM OPERATION

This is straightforward:

1. Capital, revenue and output budgets are prepared and input to the machine system.
2. Actual performance data is recorded using codings to differentiate costs by department, by cost element (e.g. labor, etc.) and by cost center (e.g., repairs and maintenance, computer time, etc.). These costs and output statistics are input to the machine system.
3. From this data the data processing system can produce capital, revenue and output budget statements (tables 1-3).
4. Input or use of a table of indirect cost centers and their mode of apportionment by department enables apportionment to be performed and an indirect cost budget statement to be produced (table 4).
5. Input or use of a table of proportions of direct and indirect departmental costs attributable to different processes enables the data
Analysis of Costs and Performance

processing system to produce a process budget statement (table 5).

6. Input or use of a table of the proportions of process costs attributable
to different "programs" enables the production of a program budget
statement (table 6).

SOME CONCEPTUAL QUESTIONS

All costs, both capital and revenue, are included in summary budget
statements to give full costs and to allow comprehensive review. The
means of dealing with capital and indirect expenditure is straightforward in practice, but is the area in which there is most room for difference of opinion on points of detail. First, there is the question as to
which items are capital expenditure and therefore apportionable to de-
partments under the heading of depreciation. Then there is the mode
do depreciation—straightline, declining balance, etc. For both capital
and indirect revenue expenditure items the most appropriate basis of
apportionment for each item is a choice which tends to vary between
institutions.

The mode of dealing with the book budget may be noted. Librarians
are used to treating the book budget as annual revenue expenditure. This type of expenditure is shown as capital—in line with accounting
practice which treats items as capital if their value is not consumed
within the normal accounting period of a year. The reason for this
practice is that otherwise the cost picture is continually distorted by
the "lumpiness" of this type of expenditure. It becomes difficult to in-
terpret changes in costs and unit costs from period to period because of
variations due to jumps in the book budget or purchases of equipment,
building work, etc. Puristically, treatment of the bookstock as a capital
item means valuing the stock. In the absence of records of any better
alternative, insurance value may be used. Practically, it is not impor-
tant to value the stock unless interlibrary comparisons are a definite
objective; the important thing is that ups and downs of current capital
expenditure should not be allowed to disguise movements in revenue
expenditure and output.

Indirect costs may be apportioned in more than one way, depending
on the object of the exercise. As illustrated in tables 4 and 5, indirect
costs have been apportioned over processes chosen as the ones whose
costs the library is most likely to want to monitor. However, if the ob-
ject was to determine the rate of charge to the user for library services,
then the costs of acquisitions, cataloging, administration and research
and development would be apportioned over the direct user services—
circulation, photocopy, reference—to give the full costs of these services.

MODELING

The budgetary system outlined operates as a fairly comprehensive formal statement of the library's operations. It is not properly a mathematical model of the library since it does not embody equations representing constraints on the library and relationships between the input and output of the library. It is possible to build in these equations and turn the budgetary system into what is sometimes called a "corporate financial-planning model." This has been done at the Sun Oil Company at the cost of ten man-years analytical time and three man-years of computer encoding. The model works and is used for budgeting, revising budgets and examining a variety of decision alternatives.

The nearest equivalent to such a model applied specifically to libraries is the University of Durham's model. This is a linear programming model which was programmed to accept details of:

1. Resources expended: staff time by staff grade; cash, seathours; and quantity of empty shelving.
2. Actual service levels: a) items acquired, b) items used inside library, and c) issued on long loan, etc.

From these substitution rates are derived: one new item stock worth the same as 1,300 user reference hours, and worth the same as ninety items on long loan, etc. This table of substitution rates is then used in subsequent calculation where resources expended or actual service levels may be altered to determine the consequences of these changes. The sort of changes which can be simulated with this model include changes in book prices, book budget, and use of different ratios and quantities of different grades of staff.

MAJOR SYSTEMS CHANGES AND LONG-RANGE PLANNING

While the budgetary system described is a very effective planning and control tool for normal purposes, special decisions call for special modes of presentation. This is the case for major capital budgetary decisions, e.g., to computerize library housekeeping procedures or to open a new library branch. Capital expenditure entails heavy present cost which is made in the expectation of reaping future benefits which may include financial savings; very often one is comparing an existing sys-
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tem having high and rising costs against a new system which has a significant implementation cost but a lower or more constant annual running cost once it is fully operational. Comparison is not fairly achieved by simple addition of the costs of both systems over a number of years. This is because money has a time value. £1 today is worth more than the expectation of £1 in five years. Even neglecting uncertainty and inflation, the £1 of today may be invested and will grow by perhaps 5 percent per year, yielding approximately £1.28 in five years. Similarly, a cost of £1 today is a heavier cost than a cost of £1 in five years. The appropriate method for comparing which takes this into account is the discounted cash-flow method. To quote Horngren: “Because the discounted cash-flow method explicitly and routinely weighs the time value of money, it is the best method to use for long-range decisions.”

Table 7 illustrates this method of comparison which is used by the United Kingdom Government Civil Service Department for evaluation of all major automated data processing projects. The department uses a ten-year projection and a 10 percent discount rate: the ten years is based on a three-year development period and an assumed seven-year computer system life. The costs of the existing and prospective systems are both projected forward over ten years. For each of the years the prospective system costs are subtracted from the existing system costs. A discount factor is applied to each of the resulting figures which are then summed to give a “present value” of the prospective system. If the present value is positive it indicates that money could be borrowed at 10 percent to support the project and this would leave finance in hand. Projects of this type will normally be supported by Her Majesty's Treasury on economic grounds, subject to reliability of estimates and countervailing noneconomic factors. If the present value is negative, the prospective system must be justified on grounds other than cost. Cost is, of course, only one criterion of system acceptability and it is always necessary to compare the other relevant advantages and disadvantages of the alternative systems—factors such as user and staff acceptability, speed of throughput, accuracy and reliability.

There appear to be no examples of full discounted cash-flow analysis in reports advocating library automation. The closest found is the cash-flow analysis presented in the final report of the South West University Libraries Systems Co-operation Project which uses the tabular method without discounting. In the same report graphical techniques are used; similar graphical analysis is used in the report of the Systems Development Project of the National Library of Canada.
This article has outlined a library management information system concerned with total library costs and performance. The system is essentially an adaptation of well-proven industrial and commercial management accounting techniques to the library context.

Faced with rising numbers of publications to purchase, rising average publication prices, rising labor costs, rising service demands, libraries are more than ever under pressure to make the resources they have go as far as possible. In this situation they are under some compulsion to apply management techniques designed to enhance their cost-effectiveness. Since there are well-proven industrial and commercial management techniques which have not been applied by libraries in any thoroughgoing way, it would be logical to make full use of these techniques. The type of system outlined offers both direct and indirect gains. By improving its budgeting and financial control, a library reaps a direct gain; by demonstrating to its funding authority that it is using the latest techniques and doing its utmost with the funds available, it reaps a further gain. In the long run a library's chance of increased budget allocations is increased by showing as clearly as possible the total picture of its present activities and future plans with associated costs and statistics.

The system described can be beneficially developed as a data processing system package. The prospects for such a package being used by number of libraries are much better than for technical processing system packages: there is more benefit in standard accounting procedures and less reason for variation. It is perhaps surprising that the library automation specialists should have concentrated on the more difficult tasks of library housekeeping and information retrieval, to the relative neglect of library management information. The fact that computers are so well-proven in industrial and commercial management information systems is another reason for anticipating a successful library management information package.
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TABLE 1
ILLUSTRATIVE CAPITAL EXPENDITURE BUDGET STATEMENT

Purposes: 1) Compare actual and budget capital expenditure for current budget period and aid setting next year's budget; and 2) show actual expenditure totals to be carried over into indirect cost budget as depreciation.

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<th>This Year's</th>
<th>Next Year's Budget</th>
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<td>Total budget</td>
<td>Budget to date</td>
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<td>Accommodation</td>
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<td>fixtures &amp; fittings</td>
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<td>Furniture, Machinery &amp; Equipment</td>
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</tr>
<tr>
<td>maps</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>music, etc.</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Totals</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>
TABLE 2

ILLUSTRATIVE REVENUE EXPENDITURE SUMMARY BUDGET STATEMENT

Purposes: 1) Compare actual and budget revenue expenditure for current budget period and aid setting next year's budget; and 2) show overall revenue cost picture which is further analyzed in indirect, process and program budgets. In practice the budget would be supported by more detailed analyses, e.g., staff costs by department.

<table>
<thead>
<tr>
<th></th>
<th>This Year's</th>
<th>Next Year's Budget</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>Budget to date</td>
</tr>
<tr>
<td></td>
<td>budget £</td>
<td>£</td>
</tr>
<tr>
<td>Direct Costs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>staff</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>material</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>expense</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Indirect Costs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>depreciation</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>repairs &amp; maintenance</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>rentals</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>other</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Totals</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>
TABLE 3

ILLUSTRATIVE OUTPUT BUDGET STATEMENT

Purpose: Show budgeted and actual output statistics for planning and control purposes.

<table>
<thead>
<tr>
<th></th>
<th>This Year's</th>
<th>Next Year's Budget</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total budget</td>
<td>Budget to date</td>
</tr>
<tr>
<td>Book selection</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>titles selected</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Book orders</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>no. orders</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cataloging</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>titles cataloged</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Circulation</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>vols. loaned</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Photocopy</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>pages photocopied</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reference service</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>number readers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Administration</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>number employees</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### TABLE 4

**ILLUSTRATIVE INDIRECT COST BUDGET STATEMENT**

Purpose: Show allocation of overhead by department as first step to allocation by process.

<table>
<thead>
<tr>
<th>Costs</th>
<th>Estimated Life</th>
<th>Basis of Apportionment</th>
<th>Departments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Tec. services</td>
</tr>
<tr>
<td>Depreciation</td>
<td></td>
<td></td>
<td>Acquisition</td>
</tr>
<tr>
<td>Buildings</td>
<td>40 yrs</td>
<td>sq. ft.</td>
<td>x</td>
</tr>
<tr>
<td>Equipment</td>
<td>5</td>
<td>% equipment</td>
<td>x</td>
</tr>
<tr>
<td>Computer</td>
<td>7</td>
<td>time</td>
<td>x</td>
</tr>
<tr>
<td>Books</td>
<td>10</td>
<td>no. books</td>
<td></td>
</tr>
<tr>
<td>Journals</td>
<td>20</td>
<td>no. journals</td>
<td></td>
</tr>
<tr>
<td>Repairs &amp; Maint.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buildings</td>
<td>sq. ft.</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Equipment</td>
<td>% equipment</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Computer</td>
<td>time</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Books</td>
<td>no. books</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rentals</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buildings</td>
<td>sq. ft.</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Computer</td>
<td>time</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Photo repro.</td>
<td>page</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insurance</td>
<td>sq. ft.</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Light</td>
<td>sq. ft.</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Heat</td>
<td>cu. ft.</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Admin. salaries</td>
<td>% staff</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Indirect labor</td>
<td>dept. use</td>
<td></td>
<td></td>
</tr>
<tr>
<td>etc.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Total Indirect Costs**

<table>
<thead>
<tr>
<th></th>
<th>$</th>
<th>$</th>
</tr>
</thead>
</table>
### Analysis of Costs and Performance

#### TABLE 5

**ILLUSTRATIVE PROCESS BUDGET STATEMENT**

Purpose: Project expected future costs, output and unit costs as part of the planning of future operations and to monitor actual performance against budget figures.

<table>
<thead>
<tr>
<th>Process</th>
<th>Direct Costs</th>
<th>Indirect Costs</th>
<th>Total costs</th>
<th>Output units*</th>
<th>Unit costs</th>
<th>Document exposure hours</th>
<th>Unit cost/ exposure hours</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Labor B A</td>
<td>Material B A</td>
<td>Expense B A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acquisition</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Catalog</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Circulation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Photocopy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reference</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Administration</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R &amp; D</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Output units:
- Acquisition = number of orders
- Catalog = number of titles cataloged
- Circulation = number of volumes loaned
- Photocopy = number of pages photocopied
- Reference = number of readers
- Administration = number of employees

† Budget to date (B) and actual to date (A) data.
TABLE 6

ILLUSTRATIVE PROGRAM BUDGET STATEMENT

Purpose: Project expected future costs as part of a plan of future operations and monitor actual performance against budget figures.

<table>
<thead>
<tr>
<th>Program and Process</th>
<th>Direct Costs</th>
<th>Indirect Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Labor (£)</td>
<td>Material (£)</td>
</tr>
<tr>
<td></td>
<td>B* A</td>
<td>B A</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Research & General Collection
   1A Acquisition  x x x x x x x x x x x x
   1B Catalog     x x x x x x x x x x x x
   1C Circulation x x x x x x x x x x x x
   1D Photocopy   x x x x x x x x x x x x
   1E Reference   x x x x x x x x x x x x
   1F Admin.      x x x x x x x x x x x x

2. Required Reading & Studying
   2A to                  x x x x x x x x x x x x
   2F                     x x x x x x x x x x x x

3. Research & Development
   3A R & D project name  x x x x x x x x x x x x
   3F Admin.             x x x x x x x x x x x x

| Total | x x x x x x x x x x x x |

* Budget to date (B) and actual to date (A) costs.
### Analysis of Costs and Performance

#### TABLE 7
**ILLUSTRATIVE DISCOUNTED CASH-FLOW PROJECTION**

**Purpose:** Set out costs of alternative capital investment/development decisions in a time related manner to aid decision on whether or not to support a proposal on cost grounds.

<table>
<thead>
<tr>
<th>Year No.</th>
<th>Projected Costs (£1000)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td><strong>Existing or Revised Manual System</strong></td>
<td></td>
</tr>
<tr>
<td>Staff</td>
<td>x</td>
</tr>
<tr>
<td>Stationery</td>
<td>x</td>
</tr>
<tr>
<td><strong>Totals A</strong></td>
<td>50</td>
</tr>
<tr>
<td><strong>Alternative or ADP System</strong></td>
<td></td>
</tr>
<tr>
<td>Staff</td>
<td>x</td>
</tr>
<tr>
<td>Stationery</td>
<td>x</td>
</tr>
<tr>
<td>Equipment hire</td>
<td>x</td>
</tr>
<tr>
<td>Computer time</td>
<td>x</td>
</tr>
<tr>
<td>Conversion costs</td>
<td>x</td>
</tr>
<tr>
<td><strong>Totals B</strong></td>
<td>60</td>
</tr>
<tr>
<td><strong>Totals A-B</strong></td>
<td>-10</td>
</tr>
<tr>
<td><strong>Discount factors</strong></td>
<td>1.0</td>
</tr>
<tr>
<td><strong>Present value</strong></td>
<td>-10</td>
</tr>
</tbody>
</table>
References

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ADDITIONAL REFERENCES


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<table>
<thead>
<tr>
<th>Title</th>
<th>Editor</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>V. 16, N. 1 Government Publications</td>
<td>Thomas S. Shaw</td>
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Forthcoming numbers are as follows:

July, 1973, Analyses of Bibliographies. Editor: H. R. Simon, Archivist and Lecturer for the Library, Zoological Institute of the University, Heidelberg, Germany.

October, 1973, Research in Fields of Reading and Communication. Editor: Alice Lohrer, Professor, Graduate School of Library Science, University of Illinois, Urbana-Champaign.

January, 1974, Evaluation of Library Services. Editor: Sarah Reed, Associate Dean, Graduate Library School, Indiana University, Bloomington, Indiana.

April, 1974, Science Materials for Children and Young People. Editor: George Bonn, Professor, Graduate School of Library Science, University of Illinois, Urbana-Champaign.