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Tutorial on Management Information Systems

Introduction

Management information is communication that leads to managerial action, and managerial action is a betterment achieved through a process of planning and control. A critical distinction in discussing management information is the difference between data and information. Data are any coded messages, considered apart from their use by an individual. Information, on the other hand, is the meaning of data to an individual. Information, therefore, is derived from data through interpretation and is ultimately a subjective phenomenon available only to the individual interpreter.

The first problem in discussing management information is to resolve the issue of subjectivity so that we might proceed with the question of system design. The field of management information systems has done this by treating as information, data that have been selectively assembled and structured so that we believe they will be useful to their recipient because we can adequately anticipate the meaning that will be gained.

Thus a discussion of management information always presupposes a recipient, a context and a use. The recipient is an individual manager in an organizational context who is engaged in decision-making activity. Management information must always be considered in light of all three of these aspects:

1. The *decision situation* includes an analysis of the type of problem being addressed, the adequacy of evidence required, and the range of normative and descriptive models available for understanding how the decision is or should be made.

2. The *organizational context* includes an analysis of the structure, style, climate, and power that characterizes the organization as well as aspects of the larger culture that impact the norms of perception, cognition, evaluation, and behavior used by its members.
3. The *individual manager* includes an analysis of the limits of cognitive ability, the dynamics of group processes, and the cognitive style that characterizes the way an individual collects and processes data.

Fundamentally, therefore, a discussion of management information cannot be value free. If we are to move beyond a discussion of mere data, then we must either affirm the status quo or propose a change in the decision situation, the organizational context or the individual manager. Either way, we take a normative position with respect to these three aspects when we make a design statement about an information system.

An appreciation of the distinction between data and information leads to a second problem in discussing management information. Data, as data, have a cost; and data, as information, have a value. In general, the cost of data increases as the amount collected increases, but the value of information does not. Information has a marginal rate of return which diminishes as its quantity increases. When we discuss the use of automation to replace existing manual processes, we can identify reductions in the cost of labor, space, time, etc. to produce a given output. Cost and value calculations, though often imprecise, can be made.

However, when we move beyond using automation to process repetitive transactions at the operational level, and explore the use of automation to enhance management decision-making, our ability to quantify the value of an information system becomes very problematic. We shift away from an assessment of efficiency and quantitative improvements toward an assessment of effectiveness and qualitative improvements in the functioning of the organization.

The two problems of data versus information and cost versus value set the stage for presenting a framework for analyzing management decision-making and a process for developing information systems to support decision-making. This paper is in four sections. Section one defines the organization as a system and the manager as a decision-maker about that system. Section two applies the framework to a library as a system. Section three derives implications for information system design, and section four explores the process of system development.

A Systems View of Organization

The systems approach is a broad label for the general attempt to understand organizations by analyzing their relational and dynamic

aspects. The organization is viewed as a set of relationships between component parts that stand apart from an environment, receiving inputs from it and producing outputs that are received by it. Thus the organization is an open system that is dependent on input and output relations with its environment, and organizes its internal components to meet those input and output demands.

Internally, each component of the organization is understood as the relationship between its own subunits as it receives input from, and produces output to other components of the organization or its environment. Thus, each level of analysis of the system (organization, component, subunit, etc.) is both a whole—with relations between subunits that must be maintained—and a part of a larger whole, with input and output relations between other parts of that whole.

Systems are seen as the nested, hierarchical organization of relatively self-contained sets of relationships between internal components, interacting by input/output processes with a larger environment. This view is important because it emphasizes that any "problem" with the organization must be understood in terms of its internal and external relations. It cannot be understood in isolation or out of context. Also, since organizations produce myriad outputs and are constituted by a very large number of relationships, the role of managers as active determinants of the problems they face (by defining inputs, outputs and relations of interest to them) is made apparent.

The basic building block of the system approach is the notion of input, process and output (see figure 1).

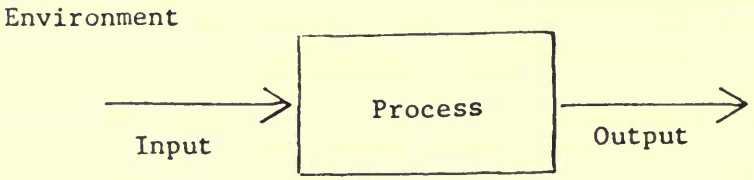

Fig. 1. Basic Input-Process-Output Model

The process can be left as an unexplained "black box," or can be expanded to include any level of detail of boxes within boxes. A very crude application to a library would be as indicated in figure 2.

As a first elaboration of this crude image, we will add the concept of levels of decision-making. The decision-maker can be viewed as making strategic, managerial or operational level decisions. At a strategic level, the

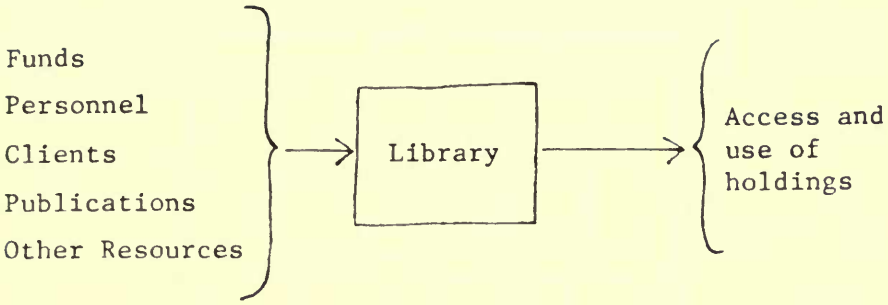

Fig. 2. Application of the Input-Process-Output Model

decision-maker is concerned with defining and prioritizing goals and objectives, and with securing the resources to achieve them. Here the manager questions and refines the basic mission of the organization—what client's are emphasized, what type and scope of services are provided, what will the character of the holdings be, what will the criteria for success and performance evaluation be?

At the managerial level, the decision-maker takes as given the resources available, the statement of mission and priorities, and the standard of performance evaluation. The problem is to arrange the operations, schedule activities, and allocate resources for the purpose of effectively achieving the strategic goals. The key idea here is effectiveness in the way the organization is configured, and the way resources are allocated.

At the operational level, the decision-maker is concerned with the details of procedures for carrying out organizational functions defined at the managerial level. Here the emphasis is on efficiency in performance, on reducing bottlenecks in flows through the system, and on removing unnecessary redundancy.

These three levels of decision-making are added to the basic input-process-output model in figure 3. Each level of decision can be further characterized by three stages of the decision-making process: intelligence, design and choice.

Intelligence. This is the initial stage of a decision process in which the manager is concerned with understanding the situation as a basis for defining the need for action or identifying the need for decision-making. The emphasis is on defining problems, threats, opportunities, and constraints that require action.

Design. At this stage, the decision-maker has identified a decision problem, and is inventing alternative courses of action and developing ideas for dealing with the problem. The recent emphasis on creativity in

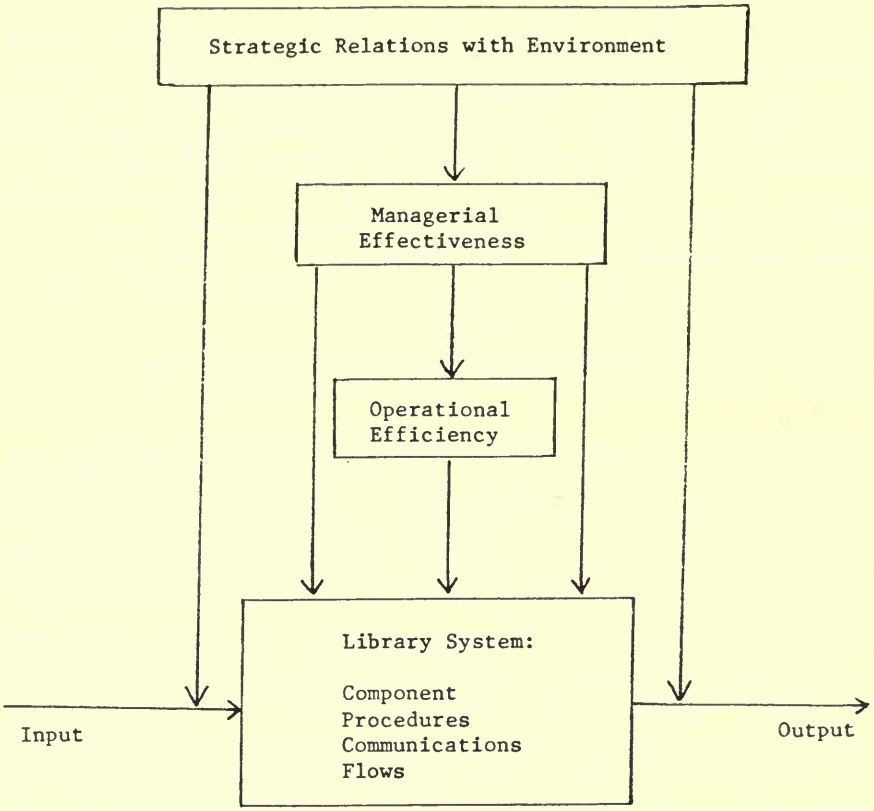

Fig. 3. Diagram of Decision-making Levels Applied to the Basic Input-Process-Output Model

management training attests to the need for more attention to this stage of the decision process.

Choice. This stage is frequently discussed as if it comprised the whole of management decision-making. Here, a course of action is selected from the set of alternatives that have been identified for meeting the needs of the problem, as it has been defined. We can treat this process as one of pure rational choice of the best alternative, or as a satisfying choice of one that is "good enough."

These stages of decision-making are not a tidy, linear sequence of steps, but are an iterative, cyclical process in which our understanding of the situation, the alternatives we are considering, and our evaluation of those alternatives interact with each other over time. The cyclic, iterative nature of decision-making is depicted in figure 4.

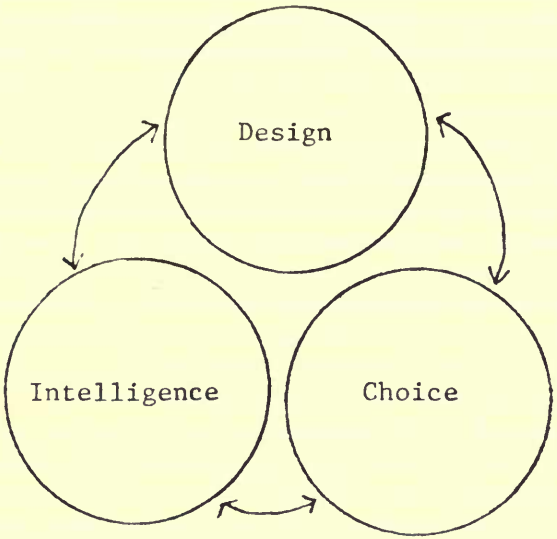

Fig. 4. Diagram of the Cycles in the Decision-making Process

Decision-making at each stage and level discussed earlier can be further characterized by the degree of "structure" they display. Structure refers to the relative ease with which we understand and accomplish the decision-making phases, and ranges from very well-structured decisions to very ill-structured ones. Well-structured decisions are those that can be fully specified such that a procedure can be designed to automate the decision-making process. Ill-structured decisions are those that remain incompletely specified and are ultimately dependent on human judgment. The basis for making those judgments rest on tacit understandings that are never fully explicated.

Recently there has been increased attention on the development of decision support systems. These systems use database, graphics, telecommunications, and simulation models to help managers make semistructured decisions where neither pure procedure, nor pure judgment prevail. The emphasis is on supporting judgment by supplementing the managers decision process with computer power in a way that is understandable and controllable by them.

So far we have introduced the notion of a system with its nested set of input, process and output relations, and we have surveyed the process of management decision-making. Now, we add the perspective of the organization as a system. For this we use the systems approach of C. West Churchman.[1] We understand organizations with a systems approach when

we think of the organization with five basic considerations. They are: (1) the resources of the system; (2) the environment of the system; (3) the components of the systems; (4) the objective of the system; and (5) the management of the system.

Resources are everything the system can draw you in carrying out its activities. This includes everything from cash and fixed assets to dependable procedures, to employee morale and client goodwill. Managers often overlook potential resources and fail to take full advantage of their possibilities.

The *environment* includes everything that is outside the system—and thereby outside of its control—that impacts the performance of the system. For the systems approach, defining the environment correctly and adapting to it successfully is the critical managerial function.

The *components* of the organization are its missions and functional programs; that which its procedures accomplish. These production processes of the organization may coincide with a departmental structure, but usually they will cross departmental lines, and are best conceived of as organization-wide programs rather than activities of isolated subunits.

The *objectives* of the organization are the goals it tends to achieve. These goals are contained in the recognized measures of accomplishment, the criteria used for performance evaluation, and the organization's definition of purpose. One must be careful to distinguish the "real" from the merely espoused objectives, and to observe how the organization actually performs when characterizing its operating objectives.

The *management* of the organization is the responsible action taken by its decision-makers. Here we emphasize the manager's involvement in planning and control decisions. Planning decisions set standards, goals and criteria over a future time horizon, and control is a process of comparing actual achievements with planned outcomes and taking corrective action as needed. This is a cybernetic feedback control process in which a standard of performance is established, and results are compared to the standard, prompting a managerical response when necessary.

Application of the Systems View to Libraries

This section presents some images of the way the systems approach can be used to observe and understand the purposeful activity of organizations. The nested cyclic, input/output transformations that characterize the systems approach, as well as the cybernetic control process, lend themselves well to the use of visual imagery.

The intent is that these visual images be used by the manager or systems analyst as a basis for exploring the set of relationships that constitutes the system, as well as a basis for generating other images and empha-

sizing other relationships. In any event, the images are convenient ways of organizing the systems concepts identified above, and applying them to a library setting.

Figure 5 presents a visual depiction of Churchman's systems approach. It emphasizes the organization's relationship with critical factors in the environment and the demand those relationships put on the system. As elements are changed, the relationships that are emphasized are changed. Also, any feature of the diagram (resources, access, acquisitions) can be further elaborated for detailed exploration. For instance, the management planning and control process can be expanded as indicated in figure 6.

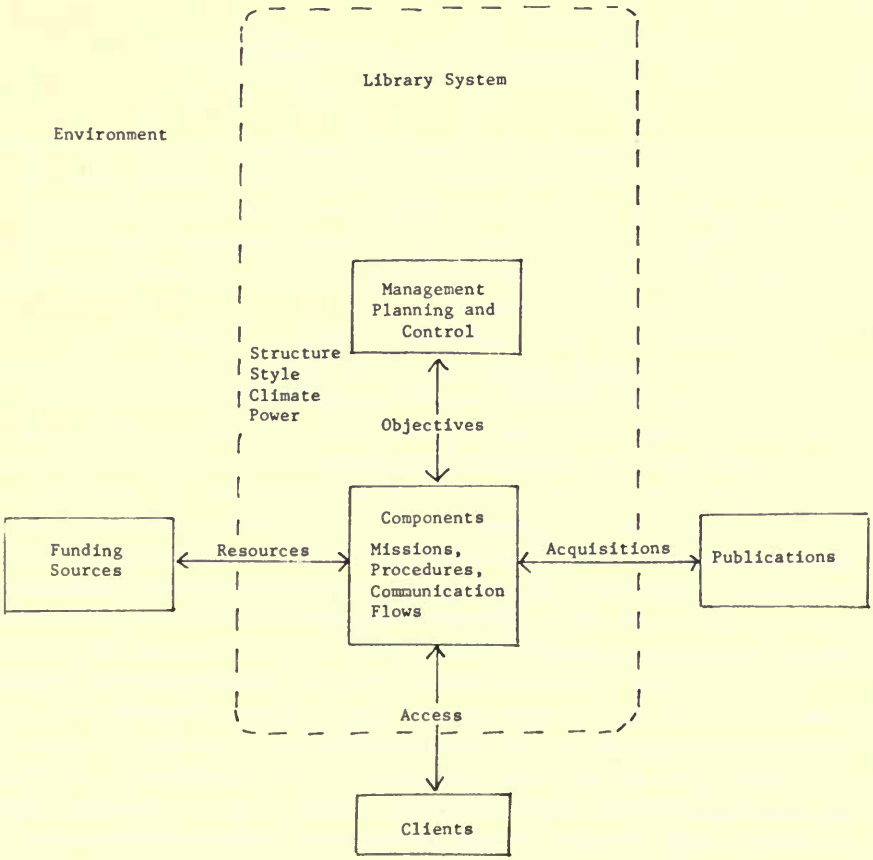

Fig. 5. Diagram of Churchman's Systems Approach

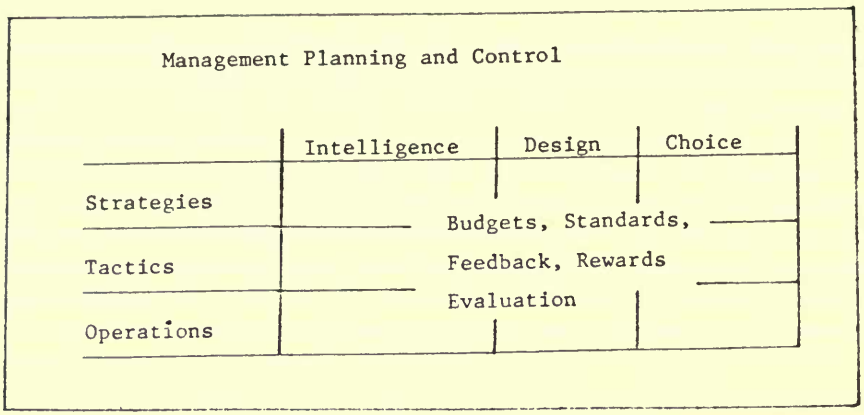

Fig. 6. Management Planning and Control Process

At any level of detail that we wish to expand the diagram, we should not only be concerned with identifying the missing details, but with assessing the overall balance of the system, and using that assessment as a basis for setting priorities. Focusing on one environmental relation while ignoring others, or emphasizing one aspect of the decision-making process over others is usually self-defeating.

The systems view also emphasizes the cyclic character of organizational processes. Figure 7 is a depiction of the library as a two-cycle system of serving clients and building a collection interacting with an environment of knowledge creation and of publications. This basic model can also be expanded, as in figure 8, to reveal subsystems in each cycle and their interrelations. The process of expansion and exploration can continue as each subsystem itself is depicted as a cycle of interrelated activities. Once again, the benefit of this type of analysis is to assist in identifying critical activities and their interrelationships, unnecessary redundancy, weakness, or overemphasis. In short, it helps to explore the question of balance among the many competing demands placed on the organization.

The final image presented in this section is that of a cybernetic control process. For each activity in the system-in-environment diagram or in the system-cycles diagrams, a control process is implied. The basic elements of that control process are shown in figure 9. The model starts with the familiar input-process-output diagram. Added to it is a monitor that measures system outputs. The outputs are then compared to a standard, goal or norm. Here the standard is shown as the prediction from a model of desired system functioning. If the comparison reveals a difference, an error message is received by the manager, who activates a change in the system, the inputs or the standard.

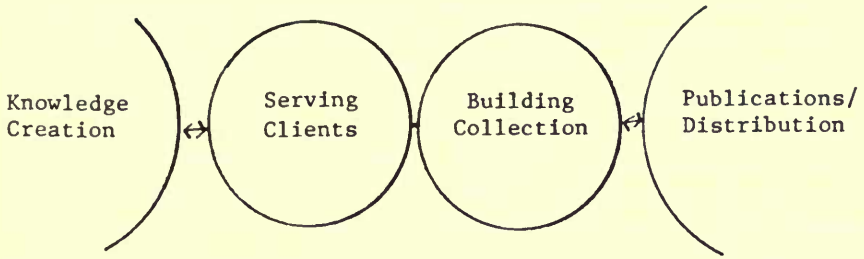

Fig. 7. Representation of the Library as a Two-cycle System

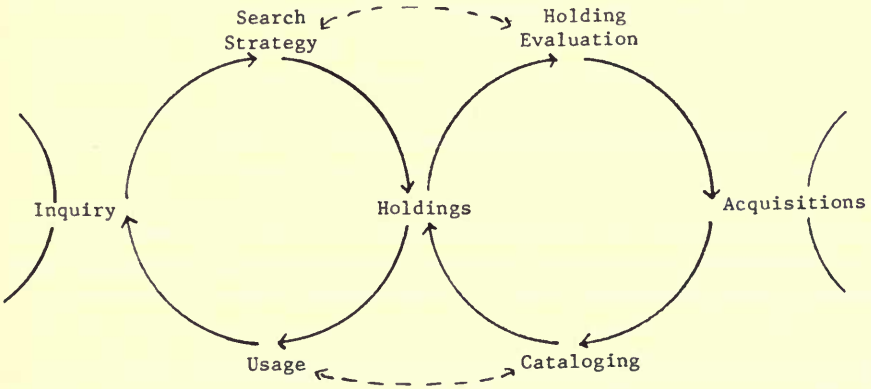

Fig. 8. The Subsystem within the Basic Two-cycle System

The word cybernetic literally means "steersman" and refers to the fact that communication processes set in motion by the output of an activity stimulate corrective responses that tend to bring the outputs back in control. Thus, the system is brought into control by the act of going out of control, and is an error-driven control process.

The cybernetic control model helps us explore the existence or adequacy of the measures of system output, the feedback communication channels, the model of desired system functioning, and the ability of a decision-maker to take corrective action in a time frame that allows the system to remain stable. If the response is too fast or too slow, the system will display oscillations around the standard, but will not converge on it.

We generally recognize three orders of cybernetic feedback control. First order feedback returns system outputs to an acceptable range, given a standard goal. Second order feedback modifies the goal itself to maintain

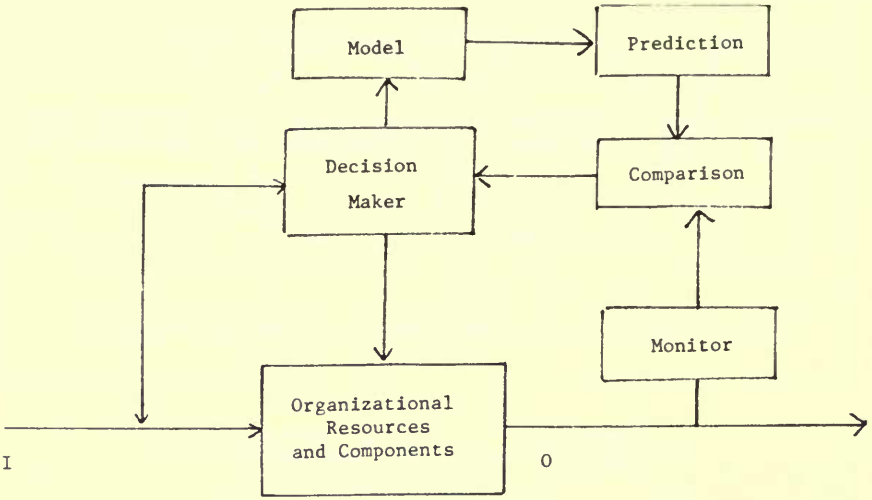

Fig. 9. Diagram of the Basic Elements in the Control Process

an overall strategy in a changing environment, and third order feedback modifies the strategy and purpose of a system based on a learning process that questions the nature of the systems relation with its environment.

Implications for Deriving Management Information from Automation

We now add to the discussion above some further considerations in designing management information systems.

The organization itself—the way it is structured with routine procedures and reporting relations—is a source of management information. These in-place procedures not only provide the positive or negative feedback that enables cybernetic control, they also define the organization's ability to sense changes in the environment, react to disturbances, handle exceptions, implement plans, achieve consensus, and revise plans. The structure and process of the organization thus deserves as much attention as the data processing support available to a particular manager.

Another consideration is that the data system must fit the organization. The style, climate and power that characterizes the management of an organization is critical to effective information system design. Is the structure based on type of client served, library function, geographic location, or a matrix combination? Is the structure centralized or decentralized, formal or informal? Is there agreement on goals? How are unit heads held accountable? What kinds of reward and status systems are in place? How

freely does formal and informal communication occur? What style of leadership does the organization display—rational persuasion, inspiration or empathy? How are these tied to the methods of motivating employees? What degree of formality, concern for the privileges of office, responsibility for worker security, and participation in decision-making characterize the organization? Where does power rest in the organization? How is it displayed and used? All these considerations are important because they contribute to the crucial difference between data and information. The data from an automated system will only be informative in an organizational context. To realize its potential value, data must lead to understanding and effective action, both of which are constrained by the organization structure.

We observe that most organizations have a limited number of critical factors that spell the difference between success and mere survival for an organization. This limited number of critical factors follows from the organization's strategic relations with its environment. Key decisions related to these critical factors is where the effort of management information support should be directed. There is practically no limit to the number of decisions and management activities that could be identified and supported with automation. Most of them are not worth the effort. The value of system development is maximized when those key decisions that affect the critical success factors receive the focus of attention and effort.

Another consideration is that a cybernetic control image emphasizes the importance of standards of evaluation and models of system performance. Unless there are standards to which actual outcomes are compared, there can be no stimulus for corrective action. Unless there is at least an implicit model of how the organization should be functioning and how decisions should be made, there is no basis for learning. The definition of standards for evaluation and the identification of the decision models managers do or should use is perhaps the most significant outcome of developing a management information system.

Data to provide management information may be generated from:

1. Reports from operations and transaction-based systems. The reports can be regularly scheduled, ad hoc, or exception based, with content tied to the level and type of decision being supported.
2. Access to database systems, both internal and external, that allow inquiry and special reports.
3. Modeling facilities that allow simulations, statistical analyses and forecasts.

In addition to database access and statistical and graphic analysis, management terminals can also offer time management, project management, message management, and teleconferencing services.

The types of decision support models that can be developed include:

1. probabilistic decision models, where the alternatives and payoffs identified by the decision-maker are combined with their expectations of the occurrence of future events;
2. deterministic simulations showing how a closed-system set of relationships behave over time. Cash flow and budget projections are classic examples of these simulations, and are the basis of financial planning and control;
3. forecasting models where historical experience of demand, usage, etc. is extrapolated to generate data for capacity planning and other purposes; and
4. optimizing models, such as linear programming, where a set of constraints are taken into account in maximizing an objective function.

Perhaps the most common type of managerial support, however, is provided by a set of search, sort and statistical programs tied to a large file representing a portfolio of objects for which the manager has responsibility. For instance, we have recently been involved in developing an acquisition support system for a media center. It consists of a file of potential acquisitions along with a boolean search procedure, sort and statistical procedures, and a report generator. In the development of the system, there were many critical technical issues that needed careful attention and which, in some instances, constrained the design. Yet, the most crucial issues in design centered on how the system was going to change the location of decision-making on acquisitions, with some people losing power and others gaining it.

Although the software of this system is powerful and flexible, its effectiveness will depend on the quality with which managers rank target areas and rate potential acquisitions. This kind of formal quantification is a new behavior that must be learned. Finally, the boolean search procedures are only as good as the questions the decision-makers will ask. The system only presents a potential, and the manager alone has the possibility to realize it which leads to the final implication.

The major reason for the failure of management support systems are organizational—not technical or economic. To be a success, the system must be implemented and used. This is a question of organizational acceptance and individual learning on the part of managers. There is no clear recipe for implementation success, but some prominent features of systems that succeed are:

1. that there is a strong felt need on the part of managers to develop the system;
2. that top administration personnel supports and fosters the effort;

3. that all affected parties are actively, meaningfully involved in the development; and
4. the system is congruent with the climate, style and power of the organization.

The System Development Process

This section gives a brief overview of an ideal system development process. The design, installation and evaluation of management support systems is a tightly woven cycle that displays an evolutionary, adaptive learning capacity. It is an iterative, recursive process that is easily separated into neat stages only in papers such as this. Figure 10 depicts the system development process as beginning with a system plan. My intention is to highlight the need to identify the critical decisions needing support based on the organization's strategic relations with its environment. The issues of efficiency versus effectiveness discussed in section one must be resolved in the planning process with a time-phased identification of priorities. The plan should chart the organization's forward movement by maintaining a balance among its key functions, and its level of managerial and technical sophistication.

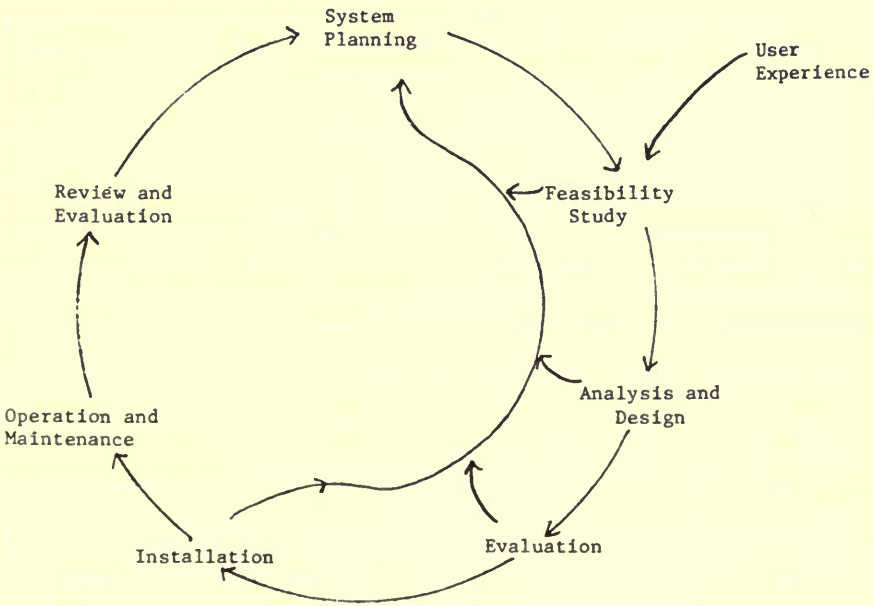

Fig. 10. Diagram of the System Development Process

The planning process, combined with the experience of user groups, creates a felt need for change and system development. It is this felt need for change which should drive system design. The feasibility study is an opportunity to assess the quality of this need and to test the economic, technical and operational validity of the proposed development. It is important here to focus on the decisions that will be supported, their significance and the impact the system will have on them. This requires that the study team understand the decision process in question, and that they do not merely assume that automation will enhance it.

The proposal should be assessed in terms of its fit with the style, climate and power of the organization and with the openness of the parties involved to accept a change. This requires that there be a dissatisfaction with the existing state of affairs and a willingness to experiment and learn new behaviors as a group, as well as at an individual level.

Analysis and design requires active involvement and support between the manager and the system analyst or technical experts. The best form of this involvement combines a sharing of design responsibility with a sense of mutual understanding, in which each participant respects and attempts to understand the perspective and concerns of the other. This type of involvement requires a significant time commitment by managers, and if they are not prepared to give it, perhaps the felt need is not as great as was at first thought.

The analysis and design stage can follow a top-down or a bottom-up progression. Top-down entails movement from goals and objectives to a logical system that meets their requirements, while bottom-up entails starting with existing procedures and processes and designing an improved system. Usually both used in conjunction with each other will prove most effective. This is because the decision process is not just a rational process of selecting best courses of action.

As mentioned above, the procedures, programs, offices, and routines are an important, organizationally-embedded source of decision-making and action. In fact, I would argue that most organizational decisions are determined by the interaction of routine organizational procedures. The decision process is also a political, disjointed one in which coalitions form and dissolve as threats and opportunities change. Any analysis that emphasizes the purely rational at the expense of appreciating the procedural and political is risking implementation failure.

An evaluation of the design should be performed before programming and testing. The risk of implementation failure should be reassessed, as well as the value of the system to the intended decisions. Designs have a way of being modified over time and this provides a test that the expected impact on crucial decisions has not been lost.

Installation, operation and maintenance are beyond the scope of this paper, except to say that structured approaches to design and programming seem to produce systems with fewer errors and less delays. Also, systems designed with structured techniques appear to require less effort for maintenance and modification. Because of the significant percentage of effort consumed by routine maintenance, this can have a major impact on the resources available for the development of new and improved systems.

Review and evaluation of systems after implementation is one step in the development process that is frequently ignored. Yet the periodic review of existing systems is necessary to weed out those that are no longer cost effective. Industrial firms that have started determined efforts at postimplementation reviews find many systems that are overly-sophisticated. These firms are freeing up computer resources by shifting these applications away from online and toward batch processing.

Perhaps most importantly, an effort at postimplementation review focuses management attention on the all important questions of assessing the efficiency and effectiveness of their organization. It requires defining desirable outcomes that can serve as a basis for measuring the quantity and quality of their output. Ultimately, this assessment of the efficiency and effectiveness of outputs, and the identification of decisions critical to their improvement is the driving force behind the entire system development process.

Conclusion

This paper has briefly covered a great deal of ground in surveying a major part of the management information system area. While it could not cover each area in the depth it deserves, the hope is to provide a framework for management information support within which the other, more detailed papers can find a common ground.

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