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ABSTRACT

A major concern in planning for and beginning the operation of the National Institute of Education is the organization's management information system (MIS). The kind of MIS needed by NIE is referred to in the literature as a "fourth generation" system--one which focuses on the decision process and which is developed in terms of maximum usefulness in management decision and control. At this stage in NIE planning, a number of general information needs can be identified. The most difficult to supply are those related to support of goal and priority setting and policy determination at the top management levels. Other clear needs relate to descriptive capability and the development of components for providing state-of-the-art information and for keeping track of ongoing programmatic efforts. Other modules must produce feedback on organizational operation, financial/accounting information, and data on the resources (other than budgetary) available to NIE. (Author/WM)

MANAGEMENT INFORMATION ISSUES AND NEEDS IN THE NATIONAL INSTITUTE OF EDUCATION

PREPARED FOR THE NIE PLANNING UNIT

by

John L. Hayman, Jr.

December 1971

COLLEGE OF EDUCATION
THE PENNSYLVANIA STATE UNIVERSITY

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SUMMARY

Rationale.--A major concern in planning for and beginning the operation of the National Institute of Education is the organization's management information system (MIS). The kind of MIS needed by NIE is referred to in the literature as a "fourth-generation" system, one which focuses on the decision process and which is developed in terms of maximum usefulness in management decision and control.

The literature and recent experience in the field indicate that, to qualify as a fourth-generation system:

1. The MIS must be oriented toward management decision and control needs, and it must serve the entire organization, including the highest management levels.
2. The system will consist of a chain of services or activities, beginning with the translation of relevant real-world events into inputs, and ending with the support of decisions. Traditional data processing is a subsequence within this larger chain.
3. Sufficient human and capital resources must be committed to the system's design, development, operation, and improvement.
4. The commitment, attention, and involvement of top management in the design, operation, and improvement of the system will be essential.
5. The MIS must be developed over time, in evolutionary fashion, and it must be dynamic in its ability to change and react to new circumstances.
6. Planning for the MIS must begin with an analysis of the decisions it is to serve, and improvement during its evolution must be based on continuous assessment of its value to decision makers throughout the organization.

7. Differences on such decision characteristics as programmability, certainty, and the need for making inferences mean that a fourth-generation information system must have great flexibility. A modular arrangement, in which file structures and input and retrieval mechanisms differ among components, is likely to be required.

8. Related to user behavior are such problems as user-system interface, timing, and formatting. The MIS must be active in the sense that it sees delivery and impact (not just storage and ready availability) as its responsibility. It must be concerned with delivering information at the time the user needs it. It also must be concerned with delivering the precise information the user needs, in the format which communicates most effectively to him.

NIE Needs and System Structure.--At this stage in NIE planning, a number of general information needs can be identified. The most difficult to supply are those related to support of goal and priority setting and policy determination at the top management levels.

Another clear need is a descriptive capability, that is, the ability to describe relevant national characteristics (the "outside environment") as they currently exist. State of the art information will be important at all levels in NIE, and the related MIS requirement is for an archival component or module which keeps track of what is accomplished in relevant fields. A separate MIS component is needed to keep track of ongoing programmatic efforts, and a complicating situation at NIE is the number and types of programs and projects which will be supported.

Part of NIE resources must be diverted to organizational operation, and the information system must produce feedback on the extent to which role expectations of units and individuals are being met.

NIE will need a computerized financial/accounting system, and, in line with the management plan being formulated, program budgeting will be employed.

Finally, one of the great problems of an organization like NIE is to know the resources (other than budgetary) available to it. Supplying this information is the task of a vendor or institutional module.

Information Systems in the Office of Education.--One of the major issues NIE will face is the extent to which it should use existing Office of Education information systems. Three agencies in OE have major information responsibilities: the Office of Administration, the National Center for Educational Statistics (NCES), and the National Center for Educational Communication (NCEC). Some of the OE information components appear to be working quite effectively, and some have major problems. NIE will need to use the descriptive statistics services of NCES and the archival services of NCEC for the time being. Whether other OE systems can be used is uncertain; their operation must be examined in more detail.

Major Information System Issues Facing NIE.--NIE must make a number of other key decisions with regard to its MIS needs. First is the matter of policy commitment to the MIS by top management. A "fourth-generation" MIS requires a long-range commitment of resources, time, personnel, and management's own involvement in planning, utilizing, and improving the system.

A major decision is the extent to which new system components need

to be developed and which should be adopted, primarily from OE. While new development appears expensive, it is sometimes the most economical approach in the long range.

One of the problems in the attempted operation of management information systems is the lack of knowledge by managers of how to utilize the system. A number of organizations have recognized that this problem can be overcome only by training managers, and NIE need to work out a management training plan.

As noted, an evolutionary approach will be necessary. At first, the NIE information system will rely almost totally on outside sources for its data input and processing needs. Designing, "bringing up," and redeveloping a new system around NIE needs will require as long as five years, and realistic expectations for the system are necessary.

A difficult question is user interface with the information system. Gaining wide support is the information center concept, in which information consultants who are experts both in retrieval from the data management system and in interpreting and supporting information inquiries are used. Whether such centers should be established in NIE, and, if so, their numbers and locations must be determined.

NIE will need to coordinate its own information activities with those of other governmental agencies and with relevant outside agencies. Involved are agreements for exchange of information, use of standardized definitions for data elements, and cooperation with such groups as the Committee on Scientific and Technical Information (COSATI).

A decision will have to be made as to the special hardware requirements for the NIE information system. These can vary from remote terminals to complete computer systems. Relative costs and benefits must be considered carefully in determining what hardware is needed.

The MIS must serve political needs as well as those related to organizational goals, and NIE should include members of the legislative and executive branches in its list of users.

Next Steps in MIS Planning.--NIE should proceed immediately with more formal planning of its management information system. As soon as possible, a full-time staff member should be appointed to handle this part of the planning effort. The person responsible for the MIS needs to attend planning and organizational meetings, and he needs continuous contact with other staff.

Major steps which should be taken in the next few months are:

1. Appoint an MIS coordinator.
2. Select an outside organization to assist in MIS conceptualization, system design, and preparation of specifications.
3. Continue to collect information on other systems. Establish working relationships with persons managing these systems.
4. Lay out performance specifications of organizational units and of individual roles within the units. Specify the related decision responsibilities.
5. Prepare and update information flow charts for NIE.
6. Establish MIS task forces for each of the major NIE units to assist in MIS planning.
7. Identify constraints on the MIS, including anticipated budgetary support, hardware and software availability, staff availability and competence, and requirements for relationships with outside agencies.
8. As NIE information needs are clarified, plan systematic tests of OE MIS units.

9. Plan a training program for NIE management.

10. Prepare a system design for the MIS. Define:

    .Users

    .Types of decisions each will make

    .Information needs associated with these decisions

    .Schedule of different types of decisions

    .Presentation (formatting) needs

    .System modules, including:

    --Data management subsystems

    --Executive monitor subsystem

    --User interface subsystem

    --Inquiry (input) subsystem

    --MIS monitoring, planning, and redevelopment subsystem.

11. Prepare detailed specifications for MIS components.

CONTENTS

MANAGEMENT INFORMATION ISSUES AND NEEDS IN THE NATIONAL INSTITUTE OF EDUCATION

I. Background and Rationale

The National Institute of Education (NIE) will be a vast enterprise which will support a major proportion of the educational research and development in the United States. NIE is being made a reality to improve the effectiveness and efficiency of educational R&D. This means, among other things, that the institution must operate under some unifying direction and theme so that its activities are not "sporatic, non-cumulative, and out of the context of useful theory" in the manner of much of the educational R&D effort in this country in the past (Wolf, 1971). It also means, quite clearly, that the products of the enterprise must have payoff in terms of demonstrable improvement in educational practice within a reasonable time.

A great deal of effort has been devoted in the last few months to an attempt to assure that NIE does in fact represent a major improvement. An obvious need is to improve the management procedures which characterized past R&D operations, and, in this regard, expert attention is being paid to current developments in management theory and management practice.

A closely related concern is the management information system (MIS) which NIE will need, and this is the matter to which this paper is addressed. It is too early in the NIE planning effort to prepare a specific design for an MIS. It is not too early, however, to lay the conceptual foundation for the system, to discuss relevant issues and needs, and to begin preliminary design work. These things are attempted in this paper. Because so much recent change has occurred in the area, the paper opens with a discussion of theoretical issues. This is intended to lay the groundwork for the most useful possible planning and development effort.

Management Information Systems--Purpose and Current Status.--A key element in any management system is the supporting information subsystem, or to use the more familiar term, the related management information system (MIS). Like the broader management field, theory and practice in information systems has undergone intense development and change in recent years. In fact, change is so rapid that what was generally defined as a management information system only three or four years ago is not acceptable as such today by those at the forefront of MIS development.

What is a currently acceptable definition? Kriebel and van Horn (1971) give the following:

> . . . a management information system is defined as the formal configuration of human and capital resources and programs in an organization that results in collecting, encoding, storing, processing, retrieving, communicating, decoding, and using data for management decision and control. The main purpose of the definition is to focus attention on the key characteristics: formal configuration, resources -- human and capital, programs, information processing activities, management decision and control (pp. 16-17).

They state further that:

> Information is the meaning or intelligence that is derived from data and used for management decision. Information is the measure of the relevance and value of data for management decision and control. For this view, the term management information acquires meaning only within an associated framework for management decision and control (p. 19).

Clearly the focus is on -- and the raison d'etre for the MIS is -- management decision and control. Marschak (1971) gives a slightly different focus with his definition:

> An information system is defined as a chain of information services: inquiring, data storing, encoding, transmitting, decoding, deciding. Each is a transformer represented, in general, by a stochastic matrix and a cost function. The inputs of "inquiring" are the benefit-relevant events, possibly statistical parameters. Actions are outputs of "deciding." Together, actions and events determine the benefits . . .
>
> The decision theory of economists and statisticians has usually neglected the sub-sequence of data storing, encoding, transmitting, and decoding. Communication engineers, on the other hand, have neglected the inquiring and deciding services and have usually equated benefit with the non-occurrence of error in the communication of data (pp. 79-80).

A comprehensive view of information system function and its relationship to decision making is part of current thinking; different aspects of the problem, which have been treated separately in the past, are being brought together. As Marschak states, the emphasis and substantive content with which one was concerned in this area in the recent past differed according to theoretical orientation, with essential parts of the total process or system neglected by those of different interests. In operating organizations, there has been still another orientation in which management information systems have been equated with data processing activities, and these often have had little relevance to actual decision processes.

Kriebel and van Horn note that a third generation of information systems (related to third-generation computers) was developed in the

mid-to-late 1960's and that these systems are still being used for the most part. They were characterized by:

> a move towards consolidation of the separate functionalized systems. The set of management function models were imbedded in a data base model that stressed data processing efficiency and effectiveness. The development orientation focused on a corporate data bank. This framework stressed input data format, flows, and files with relatively little attention to coordination or redesign of output information and end users (p. 23) . . .

Fourth-generation information systems, which will emerge in the 1970's, will utilize fourth-generation computer technology and will be based on critical decision processes in the organization. They will serve the highest levels of management as well as other parts of the organization. They will require top management attention and involvement, lack of which Kriebel and van Horn (1971) state "has been a conspicuous issue inhibiting this development strategy to date (p. 24)."

To summarize, organizational efficiency of the type NIE needs will require development of a fourth-generation information system*, and this means among other things that:

1. The MIS will be oriented toward management decision and control and will serve the entire organization, including the highest management levels.
2. A formal system will be required, and to it must necessarily be committed sufficient human and capital resources

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*First-generation information systems used mostly unit data processing (non-computer) equipment. The second-generation was characterized by the first uses of computers as MIS components. Different information functions developed separately, usually without coordination and without compatibility among components.

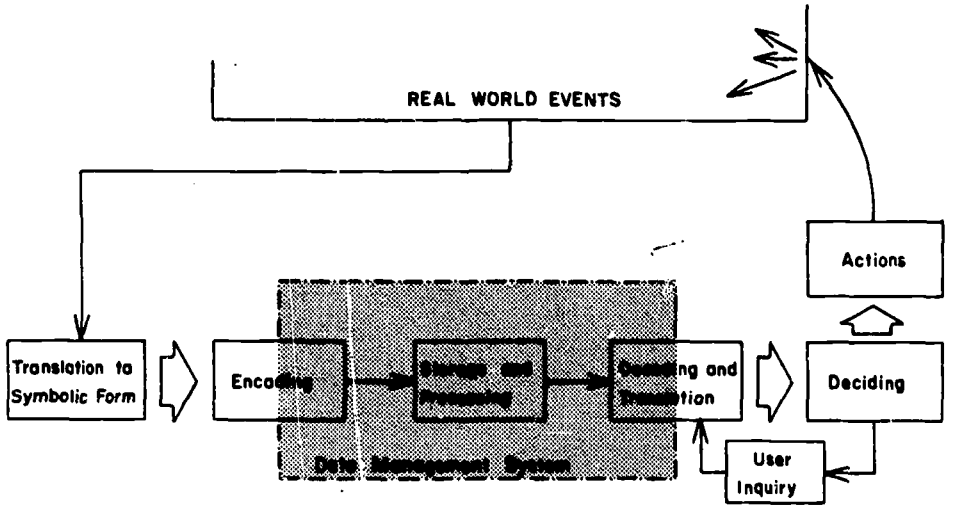
for its design, development, operation, and improvement.

3. The system will consist of a chain of services or activities, beginning with inquiry (the translation of relevant real-world events into inputs) and ending with support of decisions. Traditional data processing is a subsequence within this larger chain, and it must be made to function as an integral part of the larger chain.
4. The commitment, attention, and involvement of top management in the design, operation, and improvement of the system will be essential.

The author has talked with a number of experts in the MIS area and has read the opinions of others in the literature. Two key conclusions emerge:

1. A model MIS does not currently exist, either in industry or in any branch of government (though, as discussed later, NSF appears to be in the process of developing one),
2. The technology and theory necessary for development of a model system now exist, and this presents NIE an unusual opportunity both to further its own purposes and to lead the way in this important area in the education field.

MIS Operation.--Operation of an MIS might be portrayed graphically as in Figure 1.



MIS OPERATION

Figure 1.

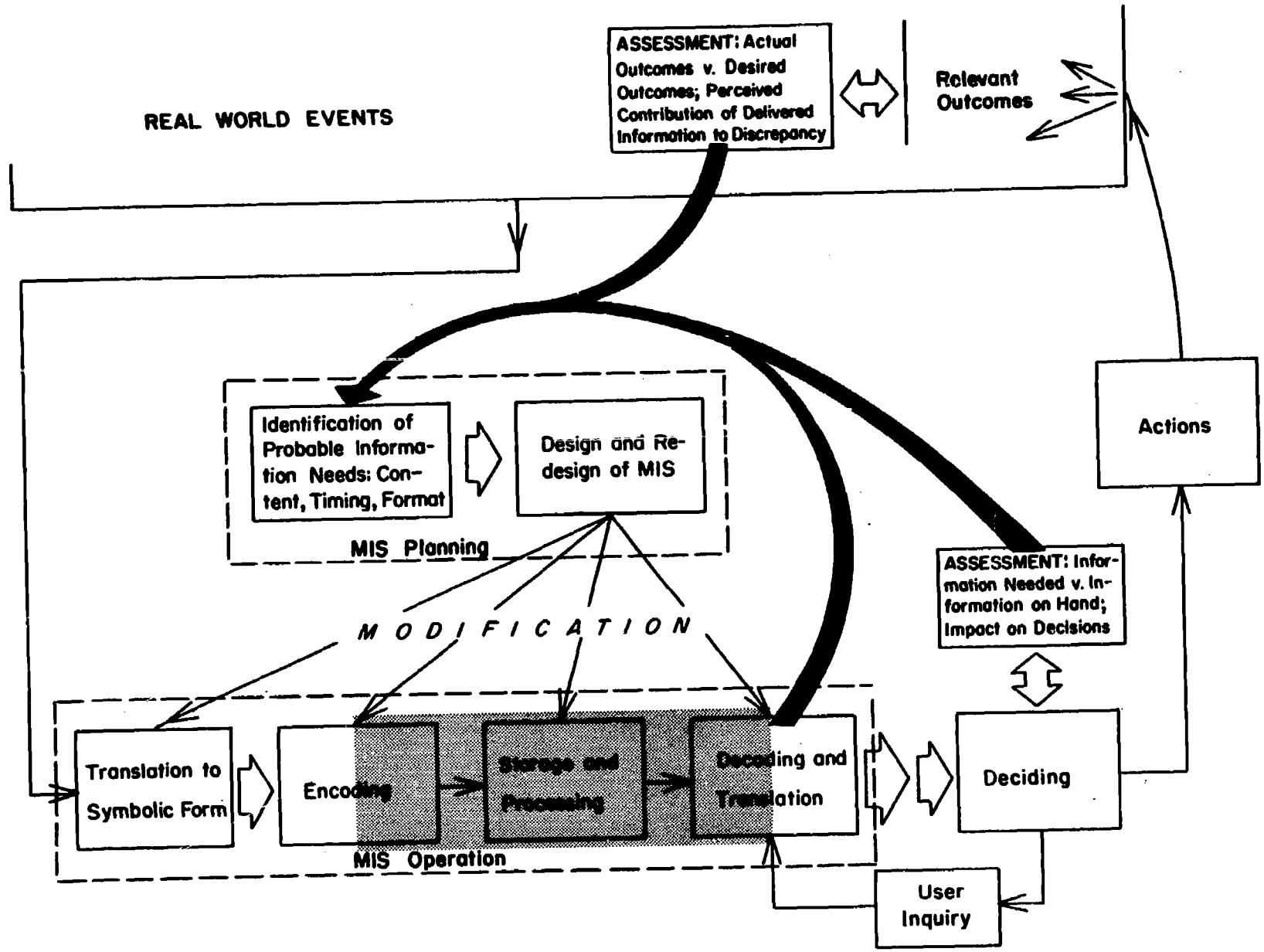
Certain relevant events in the real world are identified and translated into data, these are checked for certain characteristics (validity, file compatibility, etc.), and then are fed as input into a data management system. Some encoding activities may be performed by the formal data management system, and some may occur prior to input into this subsystem. At the other end, data is taken from the system, put into a "communicating" format, and fed as information into the decision process. Decisions are translated into actions which affect some relevant subset of real world events. The process is continuous, of course, with the inquiry subsystem sensitive to the effects of the actions on events.

This is an idealized system, and the problems in operationalizing

it are so severe that, as noted, a comprehensive operating model in an organization of any size does not appear to exist. Progress has been made recently in the "middle" activities, that is, in the set of operations which comprise the data management system. Problems exist at either end, though the greatest appear to be at the right -- in making the MIS interface with and impact the decision process. This difficulty relates to the complexity of the management and control structure and of related decision processes in organizations of any size. This point will be discussed in more detail later.

In the meantime, consider how such a system could be made to operate. Experience has shown that the picture presented in Figure 1, in which the MIS appears fixed, and only events outside of it are subject to change, is oversimplified. In fact, MIS operations are a subset of the real world events which are observed, and some of these operations must be directed toward the MIS itself. This is true for three reasons: 1) it turns out in practice that initial MIS development never results in outputs which fully meet decision needs, so that long-term developmental activity (an evolutionary approach) is essential; 2) organizational needs and functions change over time, and the MIS must change with them; 3) technology changes, and the system must be updated. The information system is embedded in a larger system, therefore, and it must continuously feed back information on its own performance and change accordingly.

A graphic representation of a dynamic MIS is given in Figure 2. This figure shows a division of the MIS into planning and operation subsystems. Experience indicates that, to get the dynamic quality necessary, this type of split is probably necessary, with decision authority in a person who



DYNAMIC MIS

Figure 2.

supervises both segments of the system and who is aware that the basic criterion for the MIS is its ability to impact management decision and control processes in a recognizable and positive way.

A more formal way to state the criterion is to note first that there is a set of organizational goals which relate to certain desired outcomes in the real world. Actions are taken in an attempt to produce these outcomes, and the value of the actions and the decisions which lead to them can be judged in terms of the discrepancy between desired outcomes and obtained outcomes. There are priorities on the outcomes, of course, and the consequences of the various discrepancies differ. Within this framework, however, the value of different outcomes can be assessed, and, assuming that the relative contribution of MIS-delivered information to decisions and to outcomes can be determined, the value of the information can in theory be assessed. This value has to be greater than the cost to the organization of operating the MIS and producing the information. Net value in these terms is the criterion -- not the efficiency with which data can be input, processed, filed, retrieved, and transmitted without error.

Churchman (1968) makes the point in this way:

> . . . one cannot use the amount of physical activity as a measure of performance of a system. One has to show how the activity is translated into a measure of utility or value (p. 108) . . . (Computer-based information systems have tended to) fail because their measure of performance is in terms of the transaction, rather than the benefit. The true benefit of an information system must be measured in terms of the meaning of information for the user (p. 112).

The measure, he says, comes by balancing the improvement in the user's behavior as a result of having the information against the cost of gaining the information.

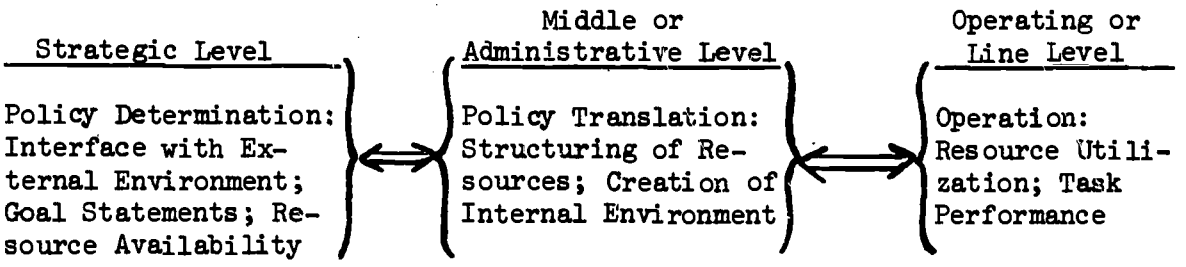
The Decision and Control Hierarchy.--The decision and control processes are the focus of system operation. As Kriebel and van Horn (1971) put it, "decision mechanisms form the unifying point of an MIS (pp. 33-34)."

The management decision process is quite complex in large organizations, and studies of and speculation about decision making are at the base of modern management theory. A major problem in developing and operating an MIS, therefore, is in establishing the necessary interface with the decision and control processes (the "deciding" box). This, obviously, depends on analyzing and understanding how these processes operate. Management theorists point out that, as a first stage in the analysis, one finds that the processes occur in hierarchies.

Anthony (1965), for example, refers to strategic planning, management control, and operational control levels of decision making. Persons in strategic planning positions decide on organizational goals, on resources needed to attain these goals, and on the policies which govern the acquisition and use of resources. Persons at the middle level, called "management control," are concerned, within the policy outlines set above, with creatively translating resources into operational procedures and schedules, replanning and redesigning procedures and schedules as problems occur, and continual checking of the extent to which the enterprise is proceeding toward stated objectives. At the bottom of the hierarchy is "operational control," and here the concern is with performing specified tasks at a predetermined quality level, according to set schedules, and within a set of constraints, including resource limitations.

Ansoff (1965) also uses three categories in a similar classification scheme, and his separation of the organization from the outside environment adds to our understanding. According to Ansoff, top management makes strategic decisions which define the interface between an organization and its external environment with respect to desired outcomes and resource availability. Administrative decisions, made by middle management, structure resources to create the internal environment of the organization. Line management makes operating decisions which determine the efficiency with which resource inputs are utilized by the organization.

The three general categories of management decision making are widely accepted, and they might be summarized as in Figure 3.



MAJOR DECISION LEVELS

Figure 3.

What this amounts to, of course, is a first cut at more precisely defining the box labeled "deciding" in the first two figures. The types of decisions made at the different levels differ, and therefore the information needs at each level differ. Decision mechanisms, the "unifying point of the MIS," turn out to be quite complex and impose a variety of demands on the MIS. The comprehensive, fourth-generation MIS must be developed to meet all of these demands.

Even this three-level scheme is oversimplified, of course, and a number of other categorizations can be made. Ansoff, for example, divides each level according to a time dimension; within each level there are short, intermediate, and long-range time frames for the decisions which need to be made. From this is derived a two-way matrix of management decisions, as shown in Figure 4. Each D in the matrix represents a decision set which can possibly be subdivided still more but which, in any event, must be considered in MIS planning.

		Time Frame		
		Short	Intermediate	Long-Range
Level	Strategic	D_{11}	D_{12}	D_{13}
	Administrative or Middle	D_{21}	D_{22}	D_{23}
	Operating or Line	D_{31}	D_{32}	D_{33}

TIME BY LEVEL DECISION MATRIX

Figure 4.

In any real-life situation, still more breaks are inevitable, according to organizational peculiarities. The value of this kind of scheme so far as NIE is concerned is that it provides a framework from which to begin the planning and development of an MIS. There is no doubt that the general outline holds, and the question is how to relate it to NIE and break it further into organizationally-specific components.

It follows from the discussion to this point that, in planning a management information system, one begins with an analysis of organizational decision roles (incumbents of which will be information users), forecasts

the decisions to be made and related information needs, and designs the system accordingly. While we have generated a general framework for at least an initial cut at classifying decision types, we need a systematic way to estimate particular information needs.

The concept "decision" is described in the literature as consisting of five activities, each of which requires definable information:

1. Intelligence, determining that a decision is needed and its nature,
2. Design, identifying possible alternative courses of action,
3. Choice, selecting the alternative which seems "best" among those available,
4. Implementation, releasing resources in pursuit of a course of action,
5. Review, following up, or comparing actions and events.

The greatest difficulty may lie with the first activity, that is, in knowing in advance that decisions will be needed and what their nature will be. This problem, alluded to before and discussed in more detail later, is the basis for the recommendation that an evolutionary approach be followed in NIE in developing an information system.

Other decision characteristics include:

.Programmability (Simon 1960) -- the extent to which precise rules for making the decision can be stated,

.Degree of certainty (Raiffa, 1968) -- the certainty or uncertainty of the conditions under which the decision is made,

.Number involved -- whether the decision is to be made by an individual or by a group.

Data management systems of the past few years have focused on lower level decisions characterized by relatively high degrees of programmability and certainty. They could deliver up hard facts, especially useful in situations where subjectivity and creativity were at a minimum. A weakness has been the inability to serve higher management levels. Fourth-generation information systems will have to overcome this problem, and doing so will require greater flexibility than has been achieved in the past. It may require multiple data management systems within a single information system. Levien (1971), for example, has reported on work with a "relational data file," a new type of data management system which is especially useful when inference must be used in deriving data from it, but which is uneconomical for such things as conventional personnel inventory or operational reporting. His system seems especially useful, in other words, at the upper management levels, those served least well by current systems.

In summary, the discussion in the second part of this section suggests that, so far as NIE needs are concerned:

1. The MIS must be developed over time, in evolutionary fashion, and it must be dynamic in its ability to change and react to new circumstances.
2. The MIS will exist to support decisions, and its value will depend totally on the extent to which management decisions are improved through use of the information it produces.
3. Planning for an MIS must begin with an analysis of the decisions it is to serve, and improvement through its "evolution" must be based on continuous assessment of its value to decision makers throughout the organization.

Decision mechanisms in large organizations are quite complex, and related information needs are likewise complex and varied.

4. Differences on such decision characteristics as programmability, certainty, and the need for making inferences mean that a fourth-generation information system must have great flexibility. A modular arrangement, in which file structures and input and retrieval mechanisms differ among components, is likely to be required. The different modules will, of course, have to communicate with each other and with the larger system.

5. Problems of user-system interface, of timing, and of formatting have not been discussed, but these obviously relate to impact on user behavior. The MIS must be active in the sense that it sees delivery and impact (and not just storage and ready availability) as its responsibility. In line with this, it must be concerned with timing, that is, with delivering information at the time the user needs it. It also must be concerned with delivering the precise information the user needs, in the format which communicates most effectively to him. As Paisley (1971) notes, "To the practitioner, if not to the archivist, one handbook or manual may be worth more than a hundred research reports (p. 3)." And Hertz (1971) has commented that, in some situations, a map can convey far more information than is possible through any other mechanism (p. 56).

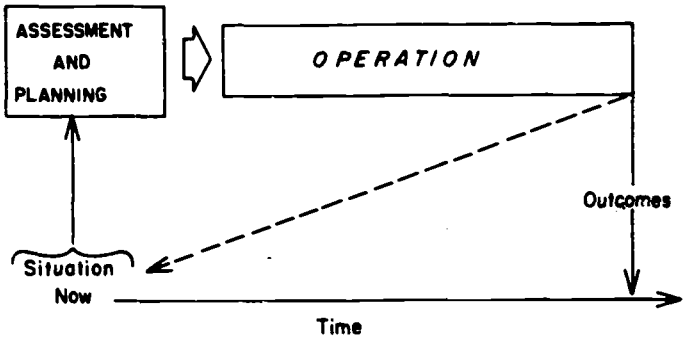
II. NIE Needs and System Structure

The organizational structure of NIE is not finalized at this time, and a detailed MIS design cannot be prepared. A good bit is known about things NIE will be doing, however. Among its wide array of activities, it will be responsible for policy determination in which the priorities and substance of educational R&D are set; for long-range planning which provides for operationalizing current policy and for systematically examining and redeveloping policy over time; for sponsorship -- and ultimate success -- of a large number of extramural programs through which national goals are achieved; for conduct of a smaller number of intramural projects and programs; and for a set of activities, including training, development, and demonstration which are intended to improve education and increase the educational research and development resources in the country. What are some information needs related to these activities?

Goal Setting and Long-Range Projections.--As discussed before, the most difficult information task is to support goal and priority setting and policy determination. There must be some mechanism for securing a national concensus on what education is supposed to accomplish and to set R&D goals within that framework. Policy determination then becomes a matter of looking at desired outcomes, looking at actual outcomes, and determining how the gap between them is to be filled. Note that this is not just a matter of getting valid information on current status or of engaging in what is now being defined as a needs assessment.

When one looks only at current status and plans in relation to it,

his outcomes, which occur later in time, are not sufficient because the situation has changed. The problem is outlined in Figure 5.



THE OUT-OF-KILTER TIME PROBLEM
Figure 5.

The solution is simple conceptually, but it is difficult to implement. The information system must include a forecasting function which can predict what the relevant conditions will be when the outcomes can be delivered. Thus, at the policy level, decision makers need to guide their activities in terms of the predicted gaps between desired outcomes and intended outcomes at some point in the future and make policy against those predictions.

In serving top management of NIE, therefore, the MIS will need to assist in the statement of national goals and priorities, forecast relevant characteristics including likely resources, and identify and evaluate various policy options. A separate module within the system might be concerned with these problems.

Description of the Outside Environment.--A clear requirement of the MIS is a descriptive capability, that is, the ability to describe relevant characteristics of the national scene. This need is long-recognized; in an 1867 act, Congress noted the need "of collecting such statistics and facts as shall show the condition and progress of education in the several

States and Territories. . ."

Note that we are concerned here with describing the outside environment. An organization works within and is influenced by its environment, and (except in the rare instance of a "closed" system) part of its purpose is to affect aspects of the environment in predetermined ways. Obviously the condition of the environment must be known.

This is the notion behind context evaluation, the "new" concept propounded by Stufflebeam (1971) and others. One must understand the influences and constraints imposed by the environment in planning his own operation, and he depends on the environment in defining some subset of his goals and priorities.

Descriptive information is also vital in evaluating the performance of an organization. A set of relevant characteristics is observed at one point in time (a base line is set), some set of activities is undertaken to produce certain outcomes, and characteristics are observed again, with degree of progress noted.

The need for a descriptive capability is evident. Building it when the environment is the total nation and the area of interest is as broad and complex as education is obviously an enormous task.

State of the Art Description.--State of the art information will be important at all levels in NIE. At the top level, the problem in one sense is to produce certain outcomes to the extent possible within available resources, and this breaks generally into two types of decisions: 1) determining the proportion of resources which should be allocated to the production of new knowledge, and 2) determining the proportion which should be allocated to the development of products based on existing

knowledge. A clear understanding of the current knowledge base is essential to these kinds of decisions.

Further down the hierarchy the concerns will be with planning and implementing programs and projects, and here it is vital to conserve resources by beginning with current knowledge -- both of theoretical and substantive matters and of methodologies.

The related MIS requirement is for some type of archival component or module. What has already been accomplished in relevant fields must be stored and readily retrievable by the system. Note that the concern is with past results (keeping in mind that five minutes ago is part of the past) -- with what has already been accomplished.

Program and Project Status.--Just as the archival component is concerned with past research and developmental outcomes, a separate component is needed to keep track of ongoing programmatic efforts. This capability is particularly important in an organization like NIE in which most of the outcomes are achieved through funded programs and projects.

In setting policy and generating resources against a background of desired outcomes, top management must have a projection of what the results of current efforts are likely to be. This is produced by the system through knowledge of what is currently going on, the quality with which it is being handled, and projected completion dates.

Middle management has the problem of translating policy through the allocation of resources, that is, of deciding which particular programs and projects to fund. It also is responsible for assuring that current efforts are carried out as intended -- that activities are occurring on schedule, that resources are being utilized at prescribed rates, and

that standards are being maintained. In allocating resources, it must understand its options, and these include among other things what is proposed by the outside R&D community.

Line management is responsible for the utilization of resources, that is, for actually carrying out programs and projects. It needs detailed information on ongoing efforts.

A complicating situation at NIE is the number of types of programs and projects which will be supported. These can be categorized at the broadest level as either basic research or development. They may be carried out within the organization, by quasi-official centers, or on an individual project basis by outside institutions and individuals.

Note that program status information needs differ in specificity as well as in kind at the different levels and according to location and type of work. To some extent, the MIS can simply aggregate and summarize as it serves higher levels. At the top, however, it must also allow for inferences and projections, and this is something quite different from preparing general summary statements.

Organizational Operation.--Part of resources go into programmatic efforts, but part must be diverted to organizational operation (including operation of the MIS). The need for performance assessment, feedback into a planning unit, and redevelopment has previously been discussed so far as the MIS is concerned. The same holds true for the complete organization, and a component of the MIS must therefore be concerned with internal operation.

The general model involves first a clear statement of role expectations of individuals and units, in terms of tasks to be performed, time

of performance, and minimum level of quality required. Feedback is in terms of the extent to which expectations are being met.

Detailed information of this type is ordinarily fed to the individual or unit concerned and to the next higher level in the hierarchy, and it normally goes beyond that only on an exception basis or in highly abstracted form. Also, a good part of the communication is often handled informally, but this is not necessarily the best way to treat it in an organization the size and complexity of NIE. As Kriebel and van Horn point out, informal information systems are labor-intensive, and, aside from the unreliability involved, their costs are increasing rapidly.

A problem in NIE is the extent to which it wishes to collect this type of information for "quasi-official" centers. Are they to be included in this component of the MIS (especially in their developing, immature period), and should they be handled in the same way as internal parts of the organization?

Financial/Accounting System.--The organization will need a computerized financial/accounting system, and little more need be said because this is the area in which current data management systems operate most effectively. In line with the management plan being formulated, a program budgeting system will undoubtedly be adopted, and this represents a change from most current accounting practice.

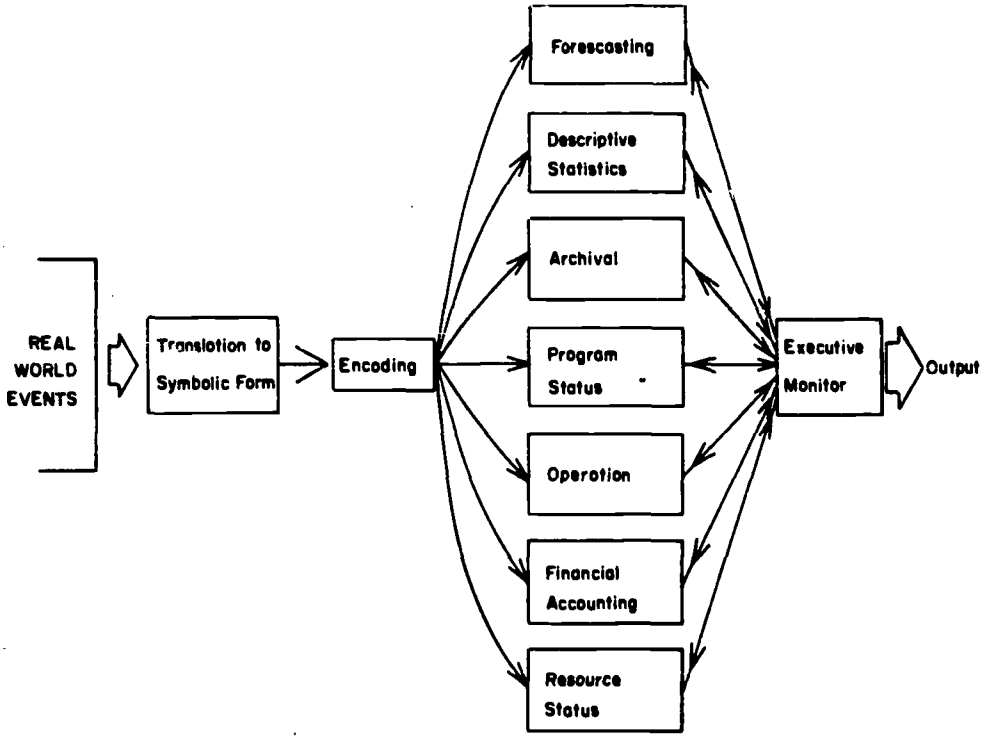
Resource Status.--One of the great problems of an organization like NIE is to know the resources (other than budgetary) available to it. What institutions and individuals are available, what is their capability, and what has been their past performance? The MIS component which delivers this type of information is sometimes referred to as a vendor or institutional file.

In a conversation with the author, Levien noted that this component should include, for each institution or individual, information on number of proposals submitted to various agencies over time, number of proposals funded, quality of the work performed, and for institutions, numbers and quality of personnel. In a sense, this amounts to a kind of monitoring of the state of the external R&D community. The need to do this on a systematic basis is widely recognized; much has been written about the lack of any comprehensive inventory of available resources.

Meeting Needs through a Modular System.--In this section we have attempted to look at some of the types of information which will be needed by NIE. The discussion is based partly on past readings and personal experience, partly on literature reviewed in connection with this project, and partly on interviews with persons in the R&D, information services, and management fields.

Perhaps as much as anything else, the discussion is intended to lay the groundwork for a modular concept in MIS planning. In the preceding section, the decision and control processes were examined and found to be complex and multidimensional. Here we have looked back at the information system and found that it, too, must be complex. If the different information types discussed here are served by separate modules, the system might be pictured as in Figure 6.

The figure is intended to indicate that the encoding process may vary according to module makeup. It also shows a new element not previously discussed -- the executive monitor. This element is needed to manage the interactions among the modules and to assure that needed information is immediately available, wherever it may be stored. The different modules



MODULAR DATA MANAGEMENT SYSTEM

Figure 6.

may have different types of file structures, and the logic for dealing with them may vary. All must be compatible with the total system, however, and all must be able to intercommunicate, though some translation step (in the executive monitor) may be necessary. This type of structure has great advantages, aside from the fact that file structures and manipulation techniques can be handled differently from one module to the

next. Single modules can be operated on and redeveloped independently of the others, modules can be eliminated, and new ones can be added, giving needed flexibility. Properly planned and operated, this arrangement prevents duplication in the collection and storage of information (a serious problem in large governmental systems). An additional advantage for NIE is that all modules do not have to be developed at once. Existing systems can be used for some modules either on a temporary or permanent basis, and development can begin on those dealing with information needs least adequately covered by what now exists.

III. INFORMATION SYSTEMS IN THE OFFICE OF EDUCATION

One of the major issues NIE will face is the extent to which it should use existing Office of Education information systems. Dimensions of this issue will be discussed later, but to lay the groundwork, a brief discussion of what now exists in OE is in order.

The fact is that there is no single information system in OE, and there is no one agency responsible for meeting all information needs. Thus, a decision maker may have to go to several agencies, and his needs (particularly the ad hoc ones which are often of vital importance) may go unmet.

This situation has developed historically and does not represent ineptness or any particular lack of insight -- at least any more than has characterized the information sciences generally -- on the part of any individual or agency. It has been compounded, however, by internal bickering and by fights over territorial prerogatives as needs have become apparent. This kind of situation can be anticipated when an attempt is made to draw together from separate organizational units common activities which have developed piecemeal. It is one reason why it is so important that management information responsibility be centralized and given top management support from the beginning in NIE.

Three agencies in OE have major responsibilities for information services: the Office of Administration, the National Center for Educational Statistics, and the National Center for Educational Communication.

The Office of Administration/Management Information Function.--In the decades after World War II, a data processing division was established

in OE, and it began basically as an accounting operation, with individual units in OE developing their own manual information files. As dependence on computer processing grew and management information concepts were better articulated, the need for a more sophisticated approach was recognized, and in 1967 the decision was made to establish an Office of Management Information (OMI). OMI continued to operate the data processing service, and it began to try to systematize information services throughout OE, i.e., it looked for communalities in input requirements, in storage files, in reporting requirements, and the like. It also began the difficult task of establishing a common vocabulary for MIS users. At first, the OMI director reported directly to the Commissioner, but in a reorganization two years ago, OMI was placed under the OE Office of Administration, and the OMI head became a Deputy Assistant Commissioner. The activity is now known as the "management information function within the Office of Administration," which we will refer to as OA/MI.

OA/MI states that its purpose is to supply information which will support decision-making activities of all levels of management in OE; it thus sees itself as a comprehensive system. It operates through two divisions: Systems Planning and Control, which includes the reporting-to-management function, and Automatic Data Processing.

Indications are that OA/MI is meeting its data processing responsibility for OE in most instances. It is obviously in the early stages in the attempt to incorporate the myriad of information activities in OE into a single unified management information system. Part of the problem lies in the piecemeal fashion in which information activities in OE grew; the most recent OMI status report notes involvement in more than 100

different "information systems," which, on examination of its representative listing, turn out to be everything from complete systems to strictly reporting devices to a proposed management information center. A more serious difficulty, in the writer's judgment, is the failure to secure adequate attention and involvement of top management, the "conspicuous issue" discussed by Kriebel and van Horn (p. 24). OA/MI is forced by circumstances into a third-generation focus -- consolidation of separate functionalized systems, data processing efficiency and effectiveness, and too little attention to design of output information and end users.

With regard to NIE needs, OA/MI can assist in information system planning, and it might serve as at least a subcomponent of the data management subsystem. Also, it appears to handle accounting/budgeting needs in OE quite well, and it might do the same for NIE or allow NIE to adopt its system. Clearly, OA/MI cannot function as the complete information system for NIE.

One of the OA/MI systems deserves special attention. This is the Project Grant Information System or PGIS. PGIS is intended to assist OE in the management of discretionary grant activities. It is thus intended to perform the function referred to in the preceding section as "keeping track of ongoing programs and projects." PGIS is meant to support all of OE, and it is a replacement of the old BRICS system which worked only within what was then the Research Bureau.

PGIS activities fall into two major categories: proposal processing and program and project management. As soon as any proposal is received by OE, it is classified according to various descriptors and taxonomy

elements and fed into the system. Its status is updated as various actions relative to it are taken until there is final disposition, either approval and funding or disapproval. After approval, the project or program is tracked through the system until completion. Among other things the system automatically generates various letters, such as those acknowledging proposal receipt and notification to members of Congress of approval.

PGIS is described as capable of generating 45 different types of reports in the following five categories:

1. Educational Intelligence Reports, which include such things as an index of all current proposals and projects, a listing of all newly approved proposals, and a listing of vendors under contract,
2. Financial Reports, which show project budgets and funding by region, Congressional district, and county; funding committed and funding obligated; and field reader vouchers for payment,
3. Status Reports, which include project resumes and summaries, overdue events, and listing of proposals for review purposes,
4. Letters, to applicants, Congressmen, etc.,
5. System Operating Reports, which show usage counts and system audit trail information, authorized descriptors, authorized educational programs, and pre-set schedules.

The system thus contains a considerable amount of information about each discretionary program or project, and this can be retrieved according to a number of characteristics, descriptors, and taxonomic codes. (A more

detailed listing of system activities and a listing of taxonomy categories are given in Appendix A.)

PGIS obviously represents an essential step forward in trying to make sense of and manage the more than 25,000 proposals OE receives each year and its more than 30,000 ongoing projects. Yet, PGIS is not operating in a satisfactory way, that is, it is not meeting management needs at OE. A number of interviews were conducted in the process of preparing this report, and the author failed to find a single decision maker who was not highly critical of PGIS. As indicated above, this may be partly a result of the critics' own lack of commitment and involvement, but it also represents a failure in system design and operation.

What is wrong with PGIS? A unanimous criticism is its inflexibility and lack of responsiveness. In spite of its many descriptors and taxonomy categories, it does not respond well to ad hoc requests. Users are dissatisfied with the information they get, and they complain about the time taken to produce it.

One explanation of the more immediate reasons why these problems exist is given in a Division of Research and Development Resources position paper. The paper notes that PGIS works well for proposal processing and for routine administration of funded projects and programs (i.e., lower level management). It does not work well for analysis and evaluation either of single projects or of groups of projects. It is poor in selective manipulation of stored data, and there is no provision for querying the system other than through one of its prescribed outputs. Also, it has no provision for the inclusion of qualitative or judgmental information. It obviously lacks the capability for inference, referred to earlier in this report.

In fairness, it must be noted that the system is still in its shake-down period, that its management is aware of many of the problems and promises that major improvements will become evident in the next few months, and that assurances of flexibility and of modification are given.

Should NIE plan to use PGIS as a component of its information system? If an answer had to be based on current PGIS performance, it would probably be no. A final decision is not necessary for some months, however, and the system can be observed and tried in a systematic way to see if promised improvements indeed become evident.

The National Center for Educational Statistics.--NCES was established as the statistical arm of OE in 1965. It is organized in three divisions: Survey Planning and Analysis, Survey Operations, and Statistical Information and Studies, and it lists among its functions:

- .Design and direction of general statistical programs of OE and conduct of special analytical studies,
- .Coordination of educational statistical programs among Federal agencies and with local, State, national, and international organizations,
- .Provision of consultative services within OE with regard to obtaining and interpreting educational data,
- .Provision of basic statistical information on the general condition and trends of education in the United States,
- .Review of plans for data collection by OE units and other Federal agencies,
- .Coordination of the development of standardized terminology and definitions for compatible recording and reporting of educational data.

NCES publishes a number of regular statistical reports; 53 titles were included in a recent listing of NCES publications. About one fourth of its resources go into the conduct of special studies (which often take

on "recurring" status after their initial completion). NCES can thus accommodate one-time or ad hoc requests, though considerable time is likely to be involved. One to two months was given as the time typically required for one-time studies, with longer periods sometimes necessary, according to the nature of the request.

NCES appears to have accomplished its purposes quite well; at least it has a good reputation within OE. It has managed to publish large quantities of obviously useful statistical data at the same time that it was making changes and improvements for the future. About every conceivable aspect of education is covered in its work.

Its plans for the future include:

1. Making provision for more longitudinal studies, and observing relationships over time.
2. Evolving the work of the Federal/State Task Force on Evaluation (the Belmont Program) into a fourth NCES division which will be responsible, among other things, for the "Common Core of Data for the Seventies" program. The intention here is to work with local and state agencies to develop composite requirements for data in a wide range of educational areas.
3. Develop broader educational performance indicators, something like the Gross National Product as an economic indicator, so that more comprehensive views of the state and progress of education will be possible. The National Assessment Program is an NCES activity which fits into this scheme.

As far as NIE is concerned, there is little question that it will rely on NCES for a good portion of its descriptive statistics. NCES is a successful operation in most respects, and any other approach would be economically prohibitive. The main problems appear to be: 1) to overcome what seems to be an undesirable time lag in responding to ad hoc requests, and 2) assuring that NIE receives priority status among NCES clientele so that it receives the service it needs. A possible approach to the former is to arrange for direct access to the NCES data base, through tape or disc transfers, and to analyze data in NIE's own shop. This will only work, of course, if the basic data is in the file in the first place.

National Center for Educational Communication.--The National Center for Educational Communication performs basically what was referred to earlier as an archival function, that is, it is concerned with information on past research and product development. NCEC has two divisions: 1) Practice Improvement, and 2) Information Resources. The Information Resources Division is divided into an Educational Materials Center, an Educational Reference Center, and an Educational Resources Information Center. The latter is the famous ERIC system, for which NCEC is best known.

ERIC, now in its fifth operational year, has three major objectives:

1. Collecting, abstracting and indexing, and making available the significant literature of the field of education,
2. Preparing reviews and syntheses to place the literature in perspective,

3. Bringing the ERIC knowledge base to the attention of practitioners, so that educational practice might catch up with its own best exemplars (Paisley, p. 11).

While ERIC has been impressive in many ways in its accomplishments, it, like PGIS, is widely criticized by its intended users. The situation is nicely summarized by Paisley (1971):

> Objectives 1. and 2. have been accomplished in fine order. ERIC can take pride in saving much of the educational report literature, generated so prolifically after the passage of the National Defense Education Act, from oblivion. A researcher can now be confident that ERIC will hold and disseminate the research reports that once disappeared after their small press runs were used up.
>
> The preparation of reviews and syntheses has also proceeded in a thoroughly professional and useful manner. Every ERIC clearing-house has a file of letters bearing unsolicited praise for the information analysis program it carries on.
>
> However, the third objective -- bring the ERIC knowledge base to the attention of practitioners -- has eluded ERIC's outreach efforts thus far. Even knowledge of ERIC's existence declines abruptly as we move from "cosmopolite" researchers and professors to "localite" administrators and teachers (p. 11).

The crucial problem of communicating with and influencing the decisions of intended users -- the basic weaknesses in third-generation information systems -- stands in ERIC's way, and this is the problem which NCEC must solve before it can claim success in achieving its objectives. Fortunately, NCEC is fully cognizant of the problem and is currently devoting a considerable proportion of its resources in the attempt to solve it.

NIE will need to use NCEC services as its main source of archival information for the foreseeable future. ERIC was originally intended to serve the outside community and not OE, incidentally, though there are current attempts to make it useful within its parent organization.

NIE will need to establish a priority position among NCEC clientele, and it will need to work with the NCEC staff in developing methods for delivering abstracted, summarized, and sometimes cross-referenced and otherwise manipulated information on short notice.

NIE will also need to develop other sources of archival information. The Smithsonian Institution's Scientific Information Exchange and the National Science Foundation's new management information system are examples of sources with which NIE may wish to establish relationships. Some additional information on systems of interest is given in Appendix B.

IV. MAJOR INFORMATION SYSTEM ISSUES FACING NIE

NIE faces a number of issues (or key decisions) it must make with regard to its MIS needs. Many of these relate directly to the previous discussion, and they will be presented below in summary form.

.Policy Commitment to the MIS by Top Management.--A fourth-generation MIS will be possible only if the top management of NIE makes the necessary commitment of resources, time, personnel, and its own involvement in planning, utilizing, and improving the system. A commitment of approximately five percent of total NIE resources to the MIS can be anticipated.

.Extent of New Development.--There is no doubt that the MIS function needs to be placed in a central office which reports high in the management structure and which handles all information needs in NIE. A major decision is the extent to which new system components need to be developed and which should be adopted, primarily from OE. While new development appears expensive, it is sometimes the most economical approach in the long range. For example, the NSF management information system was developed in parts and pieces over a number of years, in much the pattern followed in OE. There were repeated attempts to "patch it up," but the decision was finally made that the only way to fully meet organizational needs was to start over with careful planning and a unified approach and build from the ground up. This could conceivably be the most desirable route for NIE, but it is too early in organizational planning to make the decision. Rather, this option, with projected costs and benefits, should be developed as part of the planning.

.Management Training Commitment.--One of the problems in the attempted operation of management information systems is the lack of knowledge by managers of how to utilize the system -- how to recognize when information will be needed, for example, how to phrase requests for information, and how to use it in decision making when they get it. A number of corporations have recognized that this problem can only be overcome through training programs directed to managers. NSF, as a part of its overall planning, is preparing a management training program to be articulated with the beginning of operation of its new MIS. NIE has a unique opportunity in this regard in that it can start to train all of its managers at the beginning of their work with the organization.

.Sufficient Development Time and Evolutionary Character.--A mistake in many organizations, including OE in some instances, is to allow insufficient time for MIS development, that is, to expect too much from it too soon. Planning and development of an NIE information system design and of related specifications can be expected to require about two years, with outside consultant help and probably about five professional man-years invested internally. Another two to three years beyond that will be required to "bring the system up," debug it, and redevelop it to the point that it is serving users as it should. Experience has shown that users are able to specify only a small percentage of their information needs in advance and that a good deal of the development must be based on working with them and observing them as they go about their tasks. Prior training will, of course, help them contribute to this process. Continual redevelopment of the MIS over time can be expected.

This is not to say that nothing can be expected from the MIS for

four years. The system should begin producing shortly after a coordinator is named, though it will be almost totally dependent on outside data management systems in the beginning. It will take four years or more to develop a complete MIS which is built around NIE operation and needs.

.User Interface.--A difficult question is the manner of user interface with the information system, that is, the way in which users are to get the information they need from the system. As noted, current thinking places the responsibility for delivery of the "right" information on the MIS (though user "commitment and involvement" is required). Yet, how this is to be handled has not been solved in any satisfactory way. Dunlop (1971) reports an experiment at IBM in which remote terminals were placed on managers' desks -- only to be ignored. "Today's computer languages and terminal devices," he states, "prevent any real symbiosis between manager and machine (p. 219)." As an alternative, IBM developed an information center concept -- and it developed a prototype information center, manned by information consultants (or analysts) who were experts both in retrieval from the different data system components and in interpreting and supporting information inquiries. The information center concept is gaining wide support and seems a likely possibility for NIE. Whether such centers should be established, and, if so, their numbers, locations, and personnel deployment must be determined. If some other interface method is to be used, it must be planned in detail.

.Commitment to a Fourth-Generation MIS.--While this commitment is implied in some of the above issues, it has additional aspects, among them:

--Acceptance of impact on management decisions at all levels and of value in terms of contribution to achievement of organizational goals as the criteria for system success.

--At least as much stress on unpredictable (ad hoc) information needs as on regular reports. This places a premium on system flexibility and responsiveness.

--Possible inclusion of what Levien calls "relational data files" in the system.

--Development of techniques for basing inclusion of system modules and information elements within modules on anticipated net value (benefit less cost), rather than on ease of acquisition, compatability with existing files, and the like.

.Coordination with Other Federal and Outside Agencies.--NIE will need to coordinate its own information activities with those of other governmental agencies and with relevant outside agencies. Among other things, this means agreements for exchange of information, use of standardized definitions for data elements, and cooperation with such groups as the Committee on Scientific and Technical Information (COSATI).

.Hardware Requirements.--A decision will have to be made as to the special hardware requirements for the NIE information system. This can vary from remote terminals to complete computer systems. All OE information systems (except ERIC) are required to use the HEW computer center, an arrangement which is privately described as unsatisfactory in a number of instances. NSF made the decision to secure its own complete computer system. NIE will need to consider relative costs and benefits carefully

in its planning to determine if it should do likewise. A "middle" arrangement, with an intermediate size computer in NIE and concurrent reliance on a larger outside system, is another possibility.

.Interactive Interface.--A smaller, perhaps secondary, problem is the extent to which the MIS will provide for interactive interface as opposed to "batch" interface. (Can the user interact with system on a real-time basis?) Interactive interface provides greater flexibility, but it is also more costly. (In fact, a general principle is that cost increases directly with flexibility.) Some combination is likely to prove most desirable, and a method for determining when and where interactive capability is to be provided must be developed and used in MIS planning.

.Meeting Political Needs.--Needless to say, organizations based in Washington operate in a political climate, and the MIS must serve political needs as well as those related to organizational goals. A painful failure of some OE information systems has been their inability to respond to congressional information requests. NIE would be wise to consider members of the legislative and executive branches as users in its planning.

V. SUGGESTED NEXT STEPS FOR NIE IN MIS PLANNING

NIE should proceed immediately with more formal planning of its management information system. We feel that an early step, taken as soon as possible, should be the appointment of a full-time staff member to handle this part of the total planning effort. It cannot be adequately accomplished by one outside consultant working 30 percent of the time, as was the situation for the current document.

With legislative approval now assured and with other preliminary planning documents, including an organizational options report from Rand, now in hand, implementation of the NIE organization will soon begin. The person responsible for the MIS needs to be a part of the internal staff, he needs to attend planning and organizational meetings, and he needs continuous contact with other staff. He also needs to establish an ongoing relationship with persons in other governmental agencies, particularly OE, which have management information responsibilities. It would be highly desirable if this person could be the one who will ultimately assume responsibility for MIS development and operation. Preceding sections of this document make clear our conviction of the great importance of the information system to NIE, and the person chosen should be of top calibre -- one with past experience in the information services field, but with a clear understanding of and commitment to fourth-generation MIS concepts.

The MIS effort should be conducted in three phases:

I. System Design, including Preparation of Detailed Specifications.

II. System Implementation--the initial "Bringing Up".

III. System Operation and Redevelopment.

About one year will be required to produce a "first draft" system design in Phase I, with dependence on other sources for information needs while this work is in progress. The suggested major steps in Phase I, which should be taken in the next few months, are:

1. Appoint an MIS coordinator.
2. Select an outside organization to assist in MIS conceptualization, system design, and preparation of specifications.

   (We would obviously like to see Penn State in this role.)
3. Continue to collect information on other systems, with attention to such details as hardware requirements, file structure and contents, system language, input mechanisms, retrieval mechanisms, flexibility and manipulative capability, user interface mechanisms, performance history, cost, and availability. Establish working relationships with persons managing these systems.
4. In conjunction with other NIE staff, lay out performance specifications of organizational units and of individual roles within the units. Specify the decision responsibility of units and roles, including projections of decision types, time, and supporting information requirements.
5. Prepare and update information flow charts for NIE.
6. As soon as NIE organization is finalized and top staff are appointed, establish MIS task forces for each of the

major organizational units (units equivalent to those at OE whose heads are Assistant Commissioner or higher). The task forces will be responsible for assisting in the definition of information needs for their particular units.

7. As organizational planning and implementation proceeds, identify constraints on the MIS, including anticipated budgetary support, hardware and software availability, staff availability and competence, and requirements for relationships with outside agencies.
8. As NIE information needs are clarified, plan systematic tests of OE MIS units, that is, lay out a carefully designed set of requests which will test the ability of the OE units to meet NIE needs. This is particularly important with PGIS.
9. Plan a training program for NIE management.
10. Prepare a system design for the MIS, according to principles outlined in this paper. Define:

    .Users

    .Types of decisions each will make

    .Information needs associated with these decisions

    .Schedule of different types of decisions

    .Presentation (formatting) needs

    .System modules, including:

    --Data management subsystems

    --Executive monitory subsystem

--User interface subsystem

--Inquiry (input) subsystem

--MIS monitoring, planning, and redevelopment subsystem

11. Prepare detailed specifications for MIS components.

APPENDICES

APPENDIX A

Activities and Taxonomy Categories
of the Project Grant Information System (PGIS)*

1. Major Activities

.Program Management

Individual Program Management

--Documents the assignment of new Project Officer
--Coordinates the contracting of new field readers
--Approves the employment of field readers
--Notifies Congress of project approvals
--Categorizes programs by taxonomy
--Provides info on program descriptions, budget details, and status of proposals and projects

OE-Wide Program Management

Program Planning & Budgeting: Establishes a Program Authority File and generates output reports from it

Program Reporting: Provides indexes of proposals and projects
a) by Region
b) by Congressional District
c) by County and State
d) by Fiscal Year
e) by Weekly updating
f) by Taxonomy category
g) by Contract/Grant number

Program Controlling: Maintains Descriptor Authority Files (Index),
User " " " ,
Schedule " " " , and
Vendor " " " .

.Project Management

Project Organizing
--Assigns Project Officer
--Checks other projects by contractor personnel

Project Planning
--Provides info as to approval of funding of project
--Maintains pre-set schedules

Project Reporting
--Generates field reader payment requests when appropriate
--Provides info on taxonomy of projects

*From "Position Paper on the Project Grant Information System (PGIS) and the Division of Manpower and Institutions," National Center for Educational Research and Development, April 1971.

Project Controlling

--Provides info on current status of project
--Provides resume or summary of project
--Checks for related projects
--Lists due dates for scheduled events
--Records report evaluations by field readers and project officers
--Documents closeouts, amendments to project, etc.

Project Budget Control

--Provides info on funds obligated
--Coordinates processing of payment to field readers
--Updates budget info and shows expenditures to date
--Adds info on continuations of projects

.Proposal Processing

Tracks incoming proposals through varied stages such as:

--Receipt of proposal
--Assignment of Project Officer
--Assignment of Schedules
--Selection of Field Readers
--Receipt of Field Reader vouchers
--Withdrawal or rejection of proposal
--Monitoring of overdue events
--Processing continuations or supplements
--Generating Congressional notifications
--Updating program files
--Filling miscellaneous report requests

2. Taxonomy Categories

Project Description

1. Program Code
2. Phase
3. Type of Grantee
4. Project Location

Project Characteristics

5. Project Focus
6. Type Activity
7. Subject Matter
8. Results/Outcome/ Product

Ultimate Target Group

9. Demographic
10. Income
11. Special Characteristics
12. Educational Level
13. Racial/Ethnic
14. Age

Instrumental Target Group

15. Special Characteristics
16. Educational Level
17. Racial/Ethnic
18. Type

APPENDIX B

Status of Related Information Systems: NSF and the Smithsonian Science Information Exchange

Two government-related information systems outside of OE were examined in the process of preparing this report, and they deserve special mention because of their potential usefulness to NIE.

NSF Management Information System.--As noted in the body of this paper, the National Science Foundation decided more than a year ago that it could not meet its management information needs by "patching up" the different systems which had developed piecemeal. Accordingly, it set up an MIS Project Office, appointed a project director, and began the process of planning a completely new system. The project goal is "the development of a modern management information system to support day-to-day operations and to provide a strong base for planning and decision making."

Activities at NSF have been under way for several months, and they provide a current example of MIS planning and development which NIE will want to follow closely and emulate to the extent desirable. Exchange of information after NIE has its own information system operating will also be important.

The NSF MIS Project Office has shared its planning documents, prepared by project director George Pilarinos, and brief quotations will indicate the philosophy being followed:

Management of the MIS Project

1. The Project Office. The principal reasons for establishing a separate office to develop the NSF Management Information System may be summarized as follows:

a. To permit long-range MIS development to proceed without distraction from the myriad daily problems associated with running existing systems.

b. To focus responsibility and accountability for the success of the job in one place until the system is completed.

c. To provide visibility for the project and to convey management's sense of urgency and priority for attaining the objectives.

d. To permit as much flexibility as possible in carrying out the project on the one hand, while, on the other hand, stressing closer, more unified control over progress and keeping the project on course.

Project Phases and Schedule.

The MIS project can be logically divided into eight major phases for planning purposes. The phases begin at the end of the preliminary start-up stage we are now in and continue through July 31, 1973 - a total period of 27 months. It is important to note, however, that the project phases are not completely sequential and that at certain times several phases will be in effect simultaneously. The first subsystem modules should be put on the air by Mid-1972, with the total information system in place by early 1973.

1. Identification of information requirements. This phase involves the conduct of a detailed requirements study throughout the Foundation and consultation with representatives of each directorate to identify needs, in addition to a study of existing systems to determine which show promise for inclusion in the new system. Completion September 30.

2. Design of general system plan. In the latter part of phase 1, work will begin on the conceptual outline of the new management information system. Completion October 31.

3. Detailed design of subsystem specifications. After review and approval of the system concept, the detailed design of each system module can begin. Several design efforts will be going on simultaneously. As modules are completed, they would move into Phase 4. The total design job is expected to take about eight months. Completion July 31, 1972.

4. Computer Programming. This phase could begin as early as April of next year. Programming will continue until about 3 months after the last subsystem design is completed. Completion September 30, 1972.

5. Testing the subsystems. Testing (and the resulting programming changes) can begin as soon as the first module is fully programmed, possibly in March. It will continue until about 4 months after programming of the last module is completed. Completion February 28, 1973.

6. Establishment or conversion of data files for completed subsystems. As soon as successful test runs are achieved for a given subsystem the new data base can be established (or existing files converted) in preparation for full implementation. This phase will continue with succeeding subsystems with the last data base to be ready about two months after successful testing of that subsystem. Completion April 31, 1973.

7. Installation of subsystems. This phase includes installation of all of the necessary forms, equipment and work-flow changes in affected offices and training of the staff. The first major subsystem should be ready for installation about July of 1972. The final module of the last subsystem should be installed by May 31, 1973.

8. Final system adjustment and "fine tuning". When all of the subsystems are in place and working together for the first time, unforeseen bugs are likely to turn up. This phase will involve monitoring the system and making final modifications and adjustments to correct these problems. Completion July 31, 1973.

NSF information requirements have been divided into four broad classes: 1) proposal processing, 2) program management, 3) administrative operations, and 4) analytical projects. Systems and subsystems related to these classes are as follows:

1. Proposal Processing System
    a. Proposal/Application Information Subsystem
    b. Principal Investigator/Project Director/Applicant Information Subsystem
    c. "Outside" Reviewer Information Subsystem
2. Program Management System
    a. Award Information Subsystem
    b. Project/Program Status Evaluation Subsystem
    c. Award Expenditure and Fiscal Reporting Subsystem
    d. Project Property Subsystem
3. Administrative Operations System
    a. Planning, Programming, Budgeting Subsystem
    b. Program Operating Plan Subsystem

c. Financial Accounting Subsystem

d. Manpower Management Subsystem

e. Mailing List Subsystem

f. NSF Equipment Inventory Subsystem

4. Analytical Projects System

In this category, each major continuing study is considered a subsystem.

Smithsonian Science Information Exchange.--The Science Information Exchange was established in 1948 by six federal agencies to deal with research information. At first it was concerned totally with medical information. The focus of the exchange was broadened until, by the late 1950's, it included information on all of the biological sciences. It became an activity of the Smithsonian Institution in the late 1950's.

The Science Information Exchange (SIE) continued to expand until today it sees its concern as research information in all sciences. From each federal agency, including OE, SIE receives information on each funded project, and efforts are being made to expand input sources to state governments, private funding agencies, universities, and the like so that all research in the country can be included. SIE now has more than 1,000 sources and receives information on more than 100,000 research projects each year.

While the system is comprehensive, the amount of information included on each project is quite limited. It includes the supporting agency; special code numbers for the agency; project title; principal investigator, his associates, and department or specialty; the recipient institution; period; and a project summary. There is an annual update on all active projects.

SIE's greatest advantages are its comprehensiveness and its ability to group research information by subject area across agencies. In a particular area of education, for example, it can indicate what is being done at OE, NSF, the Office of Economic Opportunity, the Department of Defense, etc. SIE can respond to information requests quickly, and it can perform certain tabulations and cross-tabulations.

The greatest disadvantages of SIE are the limited amount of information on each project (a sample output sheet containing all project information is shown on the following page), inability to perform any but the most routine manipulations of project information, and delays of several months, in some cases, in getting information into the system. Some federal agencies furnish project information to SIE in blocks, only once or twice a year, and delays of more than 11 months are thus possible.

SIE provides output either in hard copy form (as illustrated on the following page), by tape interchanges, or by tabulations. It works cooperatively with all federal agencies, and its top managers have indicated a willingness to support NIE in any way possible.

The Science Information Exchange could prove very helpful to NIE in the period before NIE's own data management system is operational -- the period during which the NIE information system will have to depend on outside data management support. Certainly a close relationship with SIE should be established and the system used to the extent possible and feasible. After NIE brings up its own system, it will furnish input to SIE, and it may still have occasion to call on SIE for certain information support.

SCIENCE INFORMATION EXCHANGE
SMITHSONIAN INSTITUTION
1730 M STREET, N.W. PHONE 202-381-5511
WASHINGTON, D.C. 20036

SIE NO.
YWI-401-2

NOTICE OF RESEARCH PROJECT

SUPPORTING AGENCY:
WISCONSIN STATE GOVERNMENT

AGENCY'S NUMBER(S):

TITLE OF PROJECT:
A STUDY OF LAND DISPOSAL OF SPENT SULFITE LIQUOR AT BADGER PAPER MILLS, INC., PESHTIGO, WISCONSIN

PRINCIPAL INVESTIGATOR, ASSOCIATES AND DEPARTMENT/SPECIALTY:

TA CALABRESA PRIVATE WATER SUPPLY SECTION
D HACKBARTH UNIV. OF WISCONSIN
DA STEPHENSON UNIV. OF WISCONSIN

RECIPIENT INSTITUTION:
STATE DEPT. OF NAT. RESOURCES
MADISON, WISCONSIN 53701

PERIOD FOR THIS NRP:
7/70 TO 6/71
FY71

SUMMARY OF PROJECT:

This cooperative project provides for the determination of the extent of movement of spent sulfite liquor both in depth and laterally from the ground surface disposal areas. This project hopefully will result in determinations of: 1. The influence that the bedrock configuration has on the subsurface movement of the waste sulfite liquor. 2. The effect limerock in the area has, if any, in neutralizing some of the acidity of the waste. 3. The potentiometric distribution of the sulfite liquor both vertically and horizontally in the surficial deposits above the limerock in the vicinity of the disposal sites. 4. The aquifer characteristics both in the unconsolidated and rock aquifers. 5. The quantity of the waste reaching the river. 6. Whether the Badger Paper Mills, Inc., shall abandon the present disposal method in favor of some other treatment method insofar as the Peshtigo River is concerned. 7. Whether such land disposal practice of this type or other strong industrial waste can be safely permitted under similar geological conditions. ISG

APPENDIX C

Persons Outside of the NIE Planning Unit
Contacted During Preparation of Report

Joan Bissel
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