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ABSTRACT

This two-part paper provides a conceptual framework which surveys the process of Management Information Systems (MIS) planning and development, from need recognition to evolving MIS operational capabilities. Part 1, of direct concern to the manager, is entitled "Organizational Problem Finding." (Part 1 available as LI 002 609.) Part 2 focuses on some of the major aspects of design synthesis and the integrated planning which leads to detailed development, acquisition, implementation, and evolutionary improvement of Management Information System. A process is recommended which facilitates coordination of other internal and external organizational and system design efforts in order to reduce risk, time, and cost. (MF)

A FRAMEWORK FOR THE EVOLUTIONARY DEVELOPMENT OF AN EXECUTIVE INFORMATION SYSTEM

Part 2: System Design, Implementation, and Evolution

J. A. Evans

June 1970

This paper has been especially prepared for distribution to the California Educational Administrators participating in the "Executive Information Systems" Unit of Instruction as part of the instructional program of OPERATION PEP (Prepare Educational Planners).

THE MITRE CORPORATION

PREFACE

Under a (1968) contract with the San Mateo County (California) Superintendent of Schools, the Information Systems Division of The MITRE Corporation, in conjunction with the staff of Operation PEP* (Prepare Educational Planners), prepared a three-day Unit of Instruction on Executive Information Systems. The purpose of the course, presented in June 1968, was to support Operation PEP in its efforts to introduce some basic concepts of information systems technology to California Educational Administrators.

The presentations included in the Unit of Instruction were augmented by several reports. Three supplemented the discussions by providing general background material. The remainder, prepared as companion handouts for the individual presentations, contained copies of the visual aids (diagrams) used to emphasize significant concepts.

The present (1970) contract between the San Mateo County Superintendent of Schools and The MITRE Corporation calls for the documentation of the concepts illustrated in those diagrams and for the reissue of the supplementary reports. The objective is to provide, in one package, a complete set of references which can be used by Operation PEP in its over-all instructional program. The contents of the package, which consists of eight reports, are identified in the following list.

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*Operation PEP is funded by a U.S. Office of Education Grant Award under Title III of the Elementary and Secondary Education Act of 1965 (P.L. 89-10).

SUPPLEMENTARY REPORTS

Digital Computer Principles

J. D. Porter

Input-Output Trends

J. Mitchell

Digital Simulation and Modelling

G. B. Hawthorne, Jr.

UNIT OF INSTRUCTION REPORTS

Information System Overview

J. H. Burrows

The State-of-the-Art in Information Handling

J. K. Summers and J. E. Sullivan

A Framework for the Evolutionary Development of an Executive Information System (in two parts)

J. A. Evans

Persistent Problems in System Development

J. H. Burrows

An Information System for a District School Administrator

S. G. Lewis

Collectively, these reports provide a basic overview of information system technology; individually, they focus on some of the specific aspects associated with the design, development, implementation, and use of information systems.

A FRAMEWORK FOR THE EVOLUTIONARY DEVELOPMENT OF EXECUTIVE INFORMATION SYSTEMS

PART 2. SYSTEM DESIGN, IMPLEMENTATION AND EVOLUTION

The authors of the other papers in this series* explicitly or implicitly stress the need for management's involvement in the planning and development of formal[+] information systems. Their reasons, based on experience, are varied and solid. More important, their recommendation is not unique. A conference[±] of system professionals, held less than 10 days after the Operation PEP Unit of Instruction on Executive Information Systems, was separated in time but not in viewpoint. Those who attended the conference stress that management involvement is critical because, among other things, no viable theory of management information system exists today.

Top management's seeming detachment can, in part, be attributed to the historical emphasis in information systems: preoccupation with data processing rather than with management decision-

*See entries under Unit of Instruction Reports in Preface.

[+]As defined by J. H. Burrows in "Information System Overview" (see Preface), formal information system means computer-based information system.

[±]Held at Carnegie-Mellon University, Pittsburgh, in June 1968. Proceedings to be published in the Fall, 1970, by Prentice-Hall, Inc., under the title Management Information Systems: Progress and Perspectives; J. T. Heames, C. H. Kriebel and R. L. Van Horn (eds.).

Data: raw statements of fact.

Information: insights provided by interpretation of data.

Problem: the difference between what exists and what is desired.

As a matter of discipline we should probably think of every system as a subsystem, and during the design of a subsystem we should force ourselves to think of its relationship to some bigger system of which it is a part.

J. M. Salzer,
Evolutionary Design of Complex Systems

making processes. Thus, top management often delegated to lower-level managers the responsibility for guiding system development- managers with a functional bias (for example, marketing) who worked with system professionals with a computer subsystem bias (for example, hardware). This led to a mismatch between needs and technological aids. Both groups were overly concerned with the processing speed and manipulability of data rather than with the type of data required to support the needs of all managers. Failure to recognize the information system as a subsystem of the large organizational system may have simplified the design effort but it certainly diminished the ability of the former to support the latter. The result today is a painful recognition by both managers and system professionals that while good data processing systems are necessary to good management systems, the relationship is one of dependency and not inevitability.

The identification of requirements for the Management Information System (MIS) is the responsibility of the manager. He can hire consultants with specialized skills to help him, he can guide their efforts and integrate the results of their studies, but he cannot delegate his expertise and insights -- and thus his responsibility -- to any outsider no matter how capable. To do the job properly the manager first must acquire a systems perspective of his organization and the collective dynamic processes within it. He must replace the familiar organization chart with a conceptual delineation of the maze of integrated but separable subsystems that really are the organization. He then can begin to understand how the actions within and among the units (subsystems) relate to and impact upon each other and on the organization as an entity.

This two-part paper provides a conceptual framework that surveys the process of MIS planning and development, from need recognition to evolving MIS operational capabilities. Part 1 is of direct concern to the manager because it focuses on organizational problem-finding,* a subject little

*The growing need for the manager to do a better job of problem-finding is discussed by W. F. Pounds in "The Process of Problem Finding," Industrial Management Review, 11, Fall 1969.

In the ever-renewing society what matures is a system or framework within which continuous innovation, renewal and rebirth can occur.

John W. Gardner,
Self-Renewal
New York, Harper & Row, 1964

discussed in the literature yet crucial to MIS development. A comprehensive outline of the efforts involved in MIS development is identified and the discussions associated with the various steps indicate how the problem-finding and subsetting process can be tailored to the time and funds available.

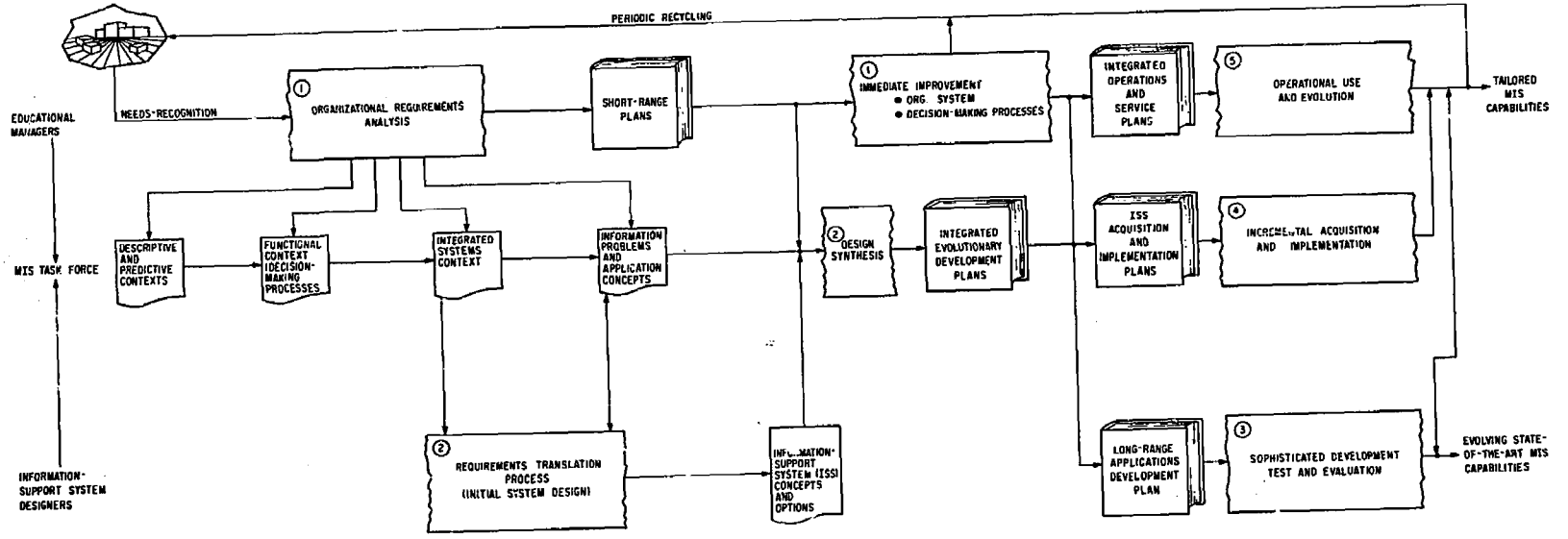
Using organizational requirements analysis as the vehicle for problem-finding, the framework allows the manager to establish contexts that will provide him with three different perspectives of his organization: as a static entity, as a network of dynamic processes, and as an integrated system. These contexts determine the degree of emphasis placed on subsequent analysis efforts. Another feature of the framework is that it encourages the manager to establish some of these contexts before he defines organizational missions, goals, and objectives. This is done because the complexity and interdependency of social-economic institutions make it difficult to structure such statements of direction out of context.

Part 2 focuses on information system acquisition, implementation, operational use, and improvement. Since this complex process is broadly discussed in available literature, activities associated with it will be highlighted only in this paper. Generally, responsibility for performance of these activities rests primarily with the information system designers. However, while they can structure alternative application concepts for the solution of information problems and estimate the costs associated with each, it still remains for the manager to determine the value of satisfying a particular need. His judgment about the relative value of alleviating various problems is much sharper as a result of participating in the organizational requirements analysis described in Part 1.

Let us now turn to an overview of the framework.

EXECUTIVE INFORMATION SYSTEMS

A FRAMEWORK FOR THE EVOLUTIONARY DEVELOPMENT



Efforts Defined by Framework

① Organizational Requirements Analysis
② Information System Design and Planning Documentation
③ Information System Development, Test and Implementation
④ Information System Acquisition and Implementation
⑤ Operational Use and Improvement of Information System

The conceptual framework (see opposite Chart) defines five major efforts (see circled numbers), and the relationship of those efforts to key products, for example, to contexts and plans (detailed documentation). The efforts are depicted as separable and each product generated as clearly relatable to a specific effort. Admittedly, this is an over-simplification of a process that, in actuality, is very complex. However, this paper does not contain a "cookbook" approach to the "x" number of procedures involved in planning and developing MIS capabilities. Its purpose is to communicate to educational managers a structured approach to thinking through organizational problem-finding (emphasis of Part 1) so that they will be better able to understand the recommendations of the information-support

system design team and guide their efforts in acquiring MIS* operational capabilities (emphasis of Part 2). In this respect, the conceptual framework serves as a useful means of communication.

As shown in the Chart, the efforts are assigned to one of three major streams in order to align them with the groups primarily responsible for carrying them out. Efforts and products identified along the upper stream are the concern of educational managers, those along the lower stream are the concern of information-support system designers, and those along the middle stream are the concern of the MIS Task Force (discussed below). Educational managers are depicted as having primary responsibility for initiating the MIS development effort, for leading the organizational requirements analysis, and for implementing immediate improvements, that is, those improvements that may not require MIS capabilities (discussed in Part 1). Thus, the manager's efforts are directed toward organizational problem-finding in order to derive the contexts and concepts which later can be translated into information-support system design

*In this paper MIS is used as a synonym for EIS (Executive Information System).

alternatives. The application concepts derived become inputs to the design synthesis effort, which is used as the bridge between Parts 1 and 2 of this paper. The option(s) selected (outputs) for acquisition as a result of design synthesis determine the contents of the integrated plans that guide the development, installation, operation and improvement of an evolving set of MIS capabilities.

The information-support system design team, which frequently includes outside consultants, is primarily responsible for conception and design of information-support system options and for providing assistance in the identification of MIS applications for long-range development, test and evaluation. Its efforts are guided by the integrated plans developed by the MIS Task Force.

The MIS Task Force includes the educational managers and information-support system designers identified above. Their participation is flexible or on an "as needed" basis. The permanent element of the MIS Task Force is a steering committee composed of top management within the organization. This committee provides continuity and guidance to the over-all effort.

The Task Force is the focal point of the MIS development effort. Early in the process it is responsible for guiding the development of the products (the contexts) of the organizational requirements analysis. These contexts are critical as a means of communicating an understanding of the organization to the information-support system design team. Effective dialogue among professionals with unique jargons must be established to ensure relevant matching of needs (as opposed to desires)* to information-support system options. The Task Force's most critical contribution is realized during design synthesis when key decisions must be made regarding the cost and value of various design options.

During the latter stages of MIS development, the Task Force's prime responsibility shifts to a complex but well-understood process: efficient acquisition and implementation of MIS capabilities. These efforts are aimed at alleviating the problems identified by the organizational requirements analysis. If the former efforts are not properly carried out, the Task Force may find that it has authorized the expenditure of substantial funds to improve what is basically a misinformation system.

*This subtle point is discussed by J. H. Burrows, op.cit. (see Preface).

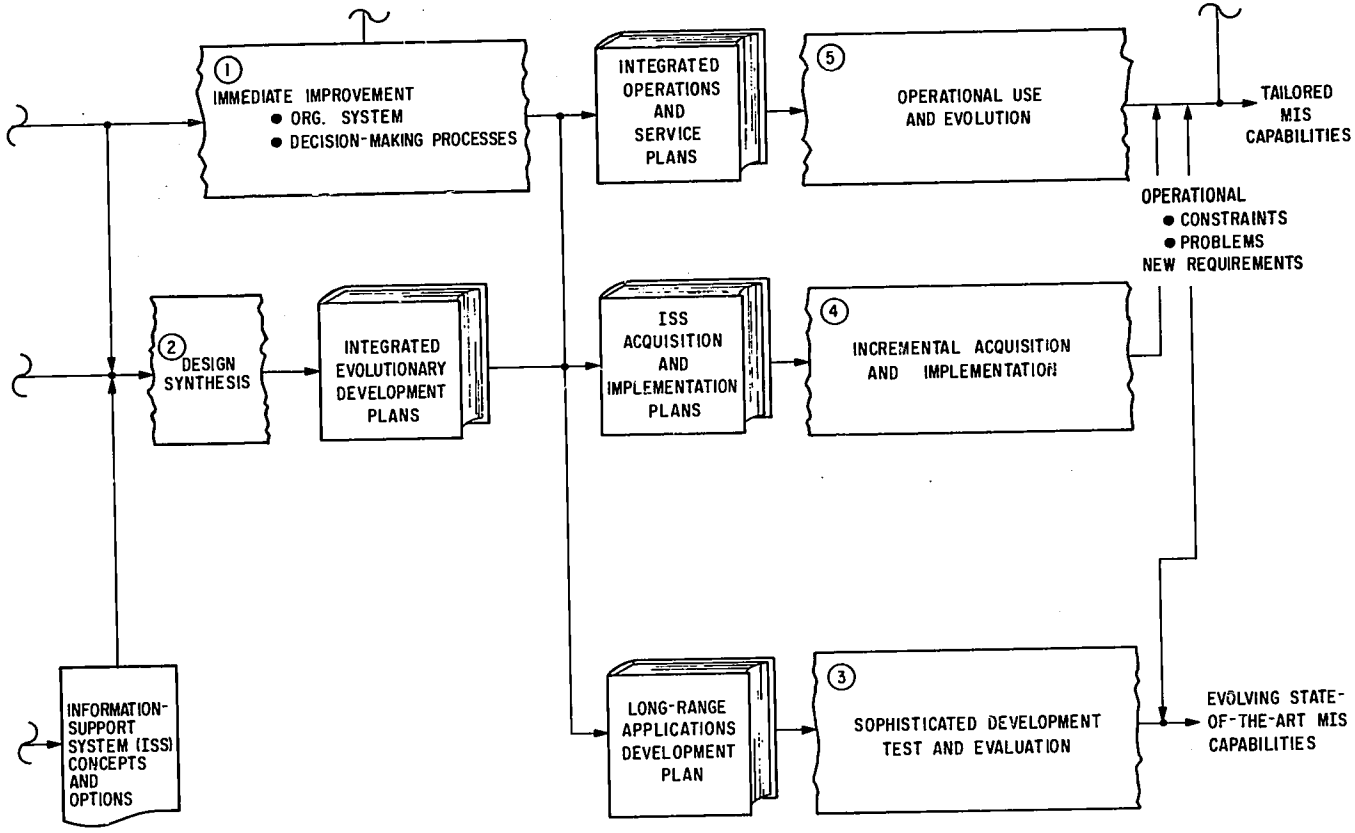
While efforts move forward over time, the conceptual framework does allow for the refinement of selective aspects of the analysis effort at two points: as immediate improvements are introduced into the organization and following operational use and evaluation of MIS capabilities. Again, this is an oversimplification because in practice efforts shown as separable are conducted concurrently and the results recycled as necessary rather than at given points. Such unscheduled recycling of data can lead to problems of mismatch between requirements and capabilities unless the modifications introduced as a result of achieving more refined results are compared with statements of requirements. For example, an immediate improvement in organizational form (recombining similar activities formerly distributed over several organizational units) may impact on requirements and hence on the MIS capability recommended. Coordination (integrated planning) therefore represents an important unstated requirement in any evolutionary MIS development effort.

The following pages provide an overview of the basic types of coordinated efforts which translate the requirements identified (Part 1) into information support system design specifications, integrated plans and operational MIS capabilities.

Even a short review of this design, implementation, and evolution process lies outside the scope of this paper and has been given a low priority in contrast to organizational problem finding because of the extent to which the literature has documented the major types of efforts and the specific steps involved. Instead, the approach taken in treating this process is to briefly describe the "downstream" part of the framework and relate the various efforts identified to the literature by means of the attached Appendices. Appendix I provides a synthesis of the major steps, time, and cost factors associated with the design, acquisition, and implementation efforts (efforts 2 and 4 in the framework). Appendix II provides a categorized bibliography which covers other essential types of effort, stressing references of particular interest to the manager. Finally, in order to give the manager a checklist-oriented appreciation for what is involved, Appendices III, IV, and V provide summarized guidelines for the design, planning and post implementation evaluation of a MIS.

EXECUTIVE INFORMATION SYSTEMS

A FRAMEWORK FOR THE EVOLUTIONARY DEVELOPMENT



An overview of the "downstream" design, implementation, and evolution process consisting of four interrelated types of efforts (2,3,4, and 5) is shown on page 15. The ISS design effort involves a synthesis of the changes being initiated in the organization and decision-making processes (as a result of earlier management involvement), the ISS options which have been informally conceived (as a result of earlier information support system design team involvement), and the formally stated requirements which have been generated by the MIS Task Force under the direction of the Steering Committee (see Part 1). In other words, the basic system design process involves the creation and synthesis of various information support system alternatives based on a familiarity with the information-handling state-of-the-art and other related interdisciplinary analysis and design techniques, and on an integrated understanding of the current and desired operational processes, problems, and applicational areas expressed via the organizational requirements analysis.

The system design process is an iterative process of variable scope requiring considerable redesign at various stages. System redesign may involve inventing an entirely new processing structure and procedures as well as obtaining new equipment. On the other hand, it may be limited to introducing new equipment to speed up to the existing process in contrast to concurrently

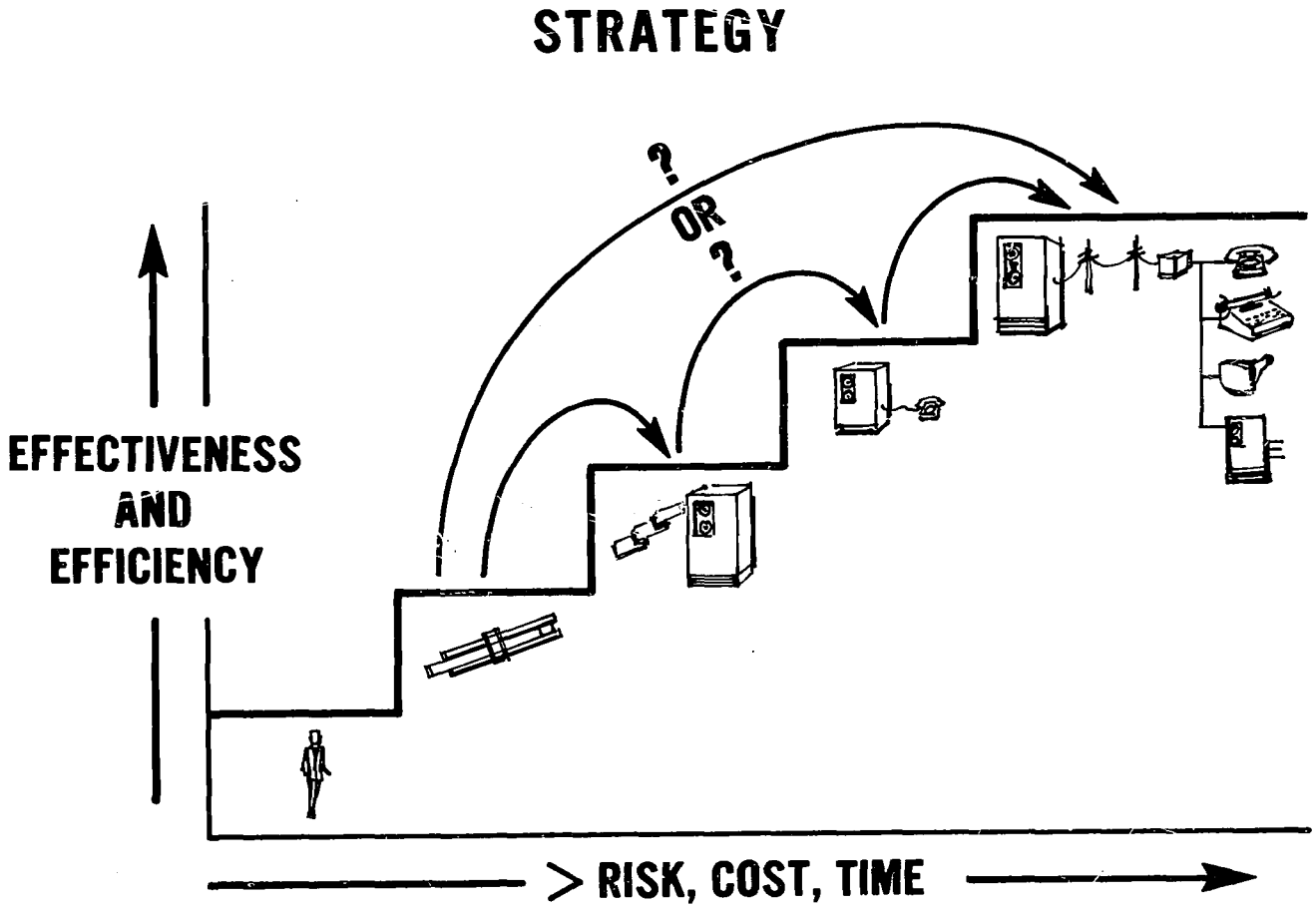
changing existing processes and creating new processes which have a ripple effect throughout the management decision-making processes and organization structure. The cautious approach is to introduce some new equipment and limit initial changes to the existing system--postponing important system changes until some later date. Though the immediate action may be limited in scope, the planning should be broader, integrated, and longer range (i.e., evolutionary) in order to assure relevant system growth after potential benefits have been demonstrated and some immediate usefulness proven.

The product of this effort leads to the development of a set of Integrated Evolutionary Development Plans which in turn initiate three separable types of efforts (3, 4, and 5). The ISS Acquisition and Implementation effort (effort 4) is typically emphasized and much discussed in the literature (see Appendices I and II). While this effort is highly visible because it leads to the doorstep arrival of computer-aided operational capabilities, the other two planning efforts are also important and more often neglected. (Appendix II provides insights into what is involved and the problems likely to be encountered under the following headings: Information Technology, Information Support System Design, and MIS Use and Evolution.)

The MIS Task Force, supported by the ISS design team, is instrumental in this design synthesis, implementation, and evolution process. The ISS design team may be a combination of in-house technical-support and outside contractor-support personnel. Collectively, it should have sufficient breadth and depth to overcome the option-proliferation problem confronting MIS designers (see Appendix I and Appendix II, reference No. 25). This problem has become especially important since the advent of operational time-sharing services in the late 1960s. The design team collectively should have a broad perspective of the range of ways in which information support requirements can be synthesized, the data base organized, and various software and hardware components configured. Since this skill diversity, in breadth and depth, is not commonly available to educational organizations, a conservative evolutionary development strategy is probably critical.*

*A conservative evolutionary MIS development strategy calls for the installation or use of a low cost, minimum operational configuration using off-the-shelf equipment which is scheduled to assume operations at the earliest possible date. (See Appendix I for a discussion of in-house or outside computer power-acquisition options which provide alternative implementation strategies for using this approach even for small local educational agencies.

EXECUTIVE INFORMATION SYSTEMS	A FRAMEWORK FOR THE EVOLUTIONARY DEVELOPMENT



Design the system from the outside in, in a series of tests of feasibility as to the attainment of the original system objective.

Orlickey, Jr., The Successful Computer System, McGraw Hill, 1969.

Two fundamental principles in designing real-time systems are balance and austerity. Balance in system design may be achieved through successful trade-offs among hardware/hardware, hardware/software, and software/software subsystems. Austerity may be pursued by developing functional requirements that do not make excessive system performance demands and by constant awareness that there is a tendency toward complexity in real-time systems.

Head, R. V., Real-Time Business Systems, Holt, Rinehart and Winston, New York, 1964.

A major strategic consideration meriting special attention in evolutionary system design is the extent and pace of computer-aiding the various decision-making processes. This particular issue is worth emphasizing because it dramatically shows why the educational manager must be involved in problem finding (Part 1) and why the development of an effective collaborative dialogue is critical to effective and efficient MIS evolution. This issue can be viewed as a basic value versus risk, cost, and time tradeoff as shown on page 19. Educational and business effectiveness and efficiency are viewed as dependent on the increasing availability of valuable information. This, in turn, is related to the completeness, accuracy, relevancy and timeliness of

data support and the increasing presence of general purpose and flexible information-support features*, on the one hand, versus increasing risk, cost, and development time on the other. Economic, political, and social costs, as well as technical costs, should be considered. This diagram shows that a wide spectrum of choice is possible, ranging from the commonly existing unaided (i.e., manual) management information systems to a sophisticated, diverse array of terminals which can be tied to a network of distributed computers (see Appendix II, Reference No. 59). These terminals could be under the control of the user organization and/or an outside information service organization (e.g., time sharing service network).

*Realizing that some applications will not be identified and that those application areas which are currently identified will have changing information requirements as management begins to substantially take advantage of these new capabilities, the question of information support adaptability and growth must also be considered. The additional cost of general purpose and flexible information support design features must be traded off to compensate for unknown application areas and those situations where changing information requirements are more likely.

How sophisticated the first increment of computer aids should be and the follow-on pace with which additional sophistication is introduced depends largely upon the effectiveness of earlier management involvement (see Part 1). More specifically, it depends upon a number of factors such as: (1) organizational, managerial and information support-system objectives and problems; (2) the short-range versus long-range sense of urgency felt by management; (3) the funds and skills available; (4) the type and status of the existing MIS systems with which the core system must interface; (5) the availability of outside capability options (e.g., software packages) and talent within the information services industry which can be purchased by the local school district, given its budget constraints. Finally, management motivation and the organizational climate is critical.

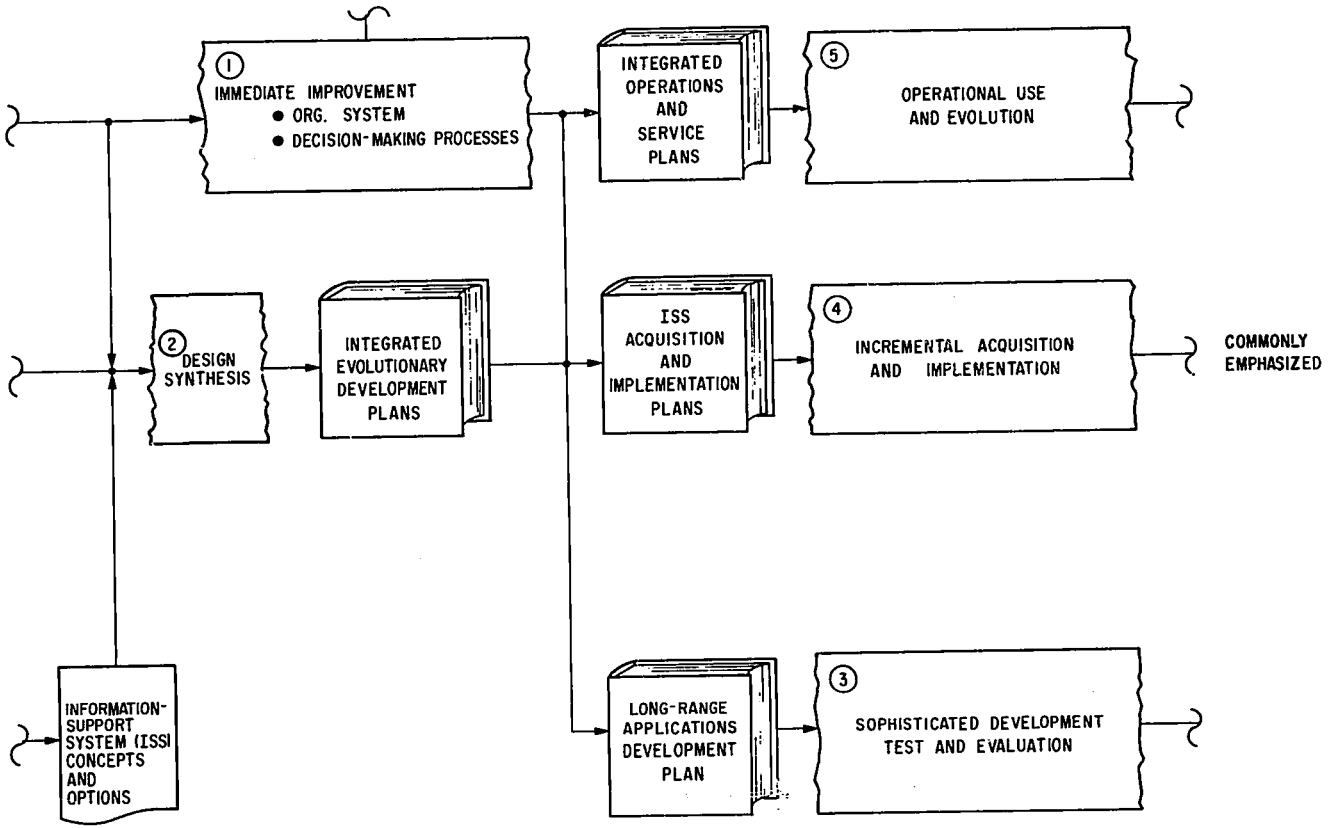
This last point is especially important. Depending upon whether the project has "grass-roots" support and is self-help oriented, or whether it is, in contrast, funded and developed from the top down, making extensive use of outside consultants and only minimally involving in-house management personnel, the outcome will be quite different. The first orientation may mean a slower start because of more extensive planning and involvement but the success of long-range evolution is considerably enhanced. The second orientation may improve short run "efficiency"

and add to a quickly implemented and "improved" reporting system, but result in abortive MIS evolution. Most of these factors cannot be properly assessed, nor can the basic value versus cost tradeoffs be made and translated into a cost/effective evolutionary strategy if management has not been substantively involved in organizational problem finding (Part 1).

More explicit guidance as to what is involved in design synthesis and evolutionary staging of an information support system is described in Appendices III and IV and in the literature (see Appendix II).

EXECUTIVE INFORMATION SYSTEMS

A FRAMEWORK FOR THE EVOLUTIONARY DEVELOPMENT



The major product of design synthesis should be multiple plans, policies, and procedures which provide guidance to various organizational groups and personnel throughout the core organization as well as to other organizations with whom the core organization must interface (see effort 3 in framework) in order to develop an Integrated Evolutionary Development Plan. The diagram on page 24 schematically highlights the three basic types of planning which should result from system design and synthesis.

The Long-Range Applications Development Plan (effort 3) focuses primarily on the identification, characterization, staging, and funding of new application areas and operational capabilities which are typically more complex and require detailed development, test, and evaluation. This effort usually requires outside support and should be sensitive to other existing educational MIS development efforts in such organizations as the state education agency, the regional educational laboratories, and the information services organizations (e.g., time sharing services and service bureaus). By developing an awareness of other related or relatable MIS development efforts, organizations, and personnel who are involved in these efforts at an early stage in MIS development, valuable "lessons-learned" experience and considerable development insight can be obtained funding sources identified, compatibility problems negotiated,

and joint proposals prepared, resulting in considerable savings in time and effort to the core organization.

The ISS Acquisition and Implementation Plan (effort 4) must also be prepared especially when a significantly different and complex Management Information System or special capability is to be acquired and installed. This plan should first describe the operation of the new system capability in terms of: (1) requirement-responsive information flows and uses of the system by the core organization; (2) equipment configurations; (3) personnel organization and training; (4) acquisition phase-over and conversion; and (5) "justification" of the new system by discussing its benefits and cost (see Appendix V for Guidelines to Benefit and Cost Analysis).

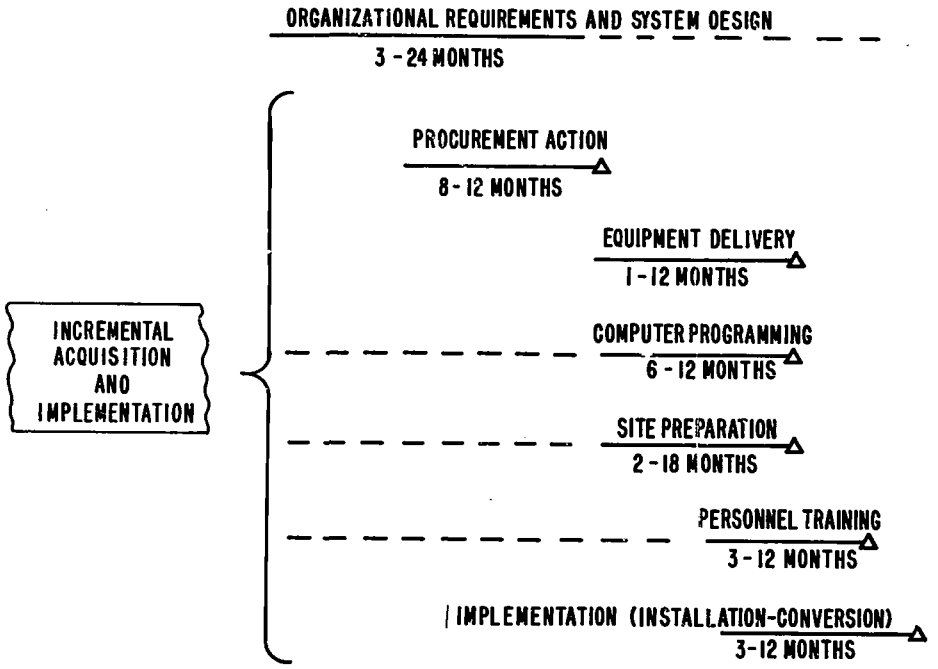
Plans must also be developed (effort 5) by the core organization's internal management at all levels which anticipate the impact of MIS development on the management and organization of currently-effected activities and services. The short-range improvements which may already be taking place as a result of the earlier organizational requirements analysis, the disruption in day-to-day activities caused by the arrival of significantly different computer-based MIS opera-

tional capabilities, and the planned long-range acquisition of more complex capabilities must be assessed and their impacts on current information support, management decision-making, and organizational structure translated into an integrated renewal effort.

In short, evolutionary development planning should encompass management and organizational development planning and be integrated with the information support planning in order to achieve effective renewal. Integrated evolutionary planning should also encompass both short- and long-range efforts which are ongoing or planned by managers inside the core organization and by other organizations outside of the core organization which may at some point impact on MIS evolution. This integrated evolutionary development effort will assist managers to shift from a crisis reaction mode of operations to the more effective management of planned change.

Too often a typical emphasis has been on ISS system acquisition and implementation exclusively, involving primarily the new manager of the information support system (after the phaseover of the MIS Task Force project to a permanent MIS department) and those other operational control level managers who will be immediately affected by the arrival of initial MIS capabilities. To the extent that these other types of planning efforts are not

MAJOR MILESTONES



FACTORS AFFECTING TIME AND COST

- DEGREE OF CONCURRENCY
- SCOPE OF DEVELOPMENT EFFORT
- DEGREE OF MANAGEMENT COORDINATION
- STABILITY OF REQUIREMENTS
- QUALITY OF DOCUMENTATION
- RESOURCES COMMITTED
- ACTUAL TIME AVAILABLE

initially thought through (see Appendix IV for System Planning Guidelines) and integrated with the installation of an information support system, fragmented failure (i.e., high costs, schedule slippage, low management morale and organizational turmoil) will result.

This most visible and tangible type of effort -- the ISS acquisition and implementation effort -- merits additional discussion in order to more easily convey its essence and relate it to the literature. A review of military, industrial, and governmental organizational experience over the past ten years reveals the presence of six basic steps which are presented on page 28 in the form of milestones which typify this type of effort. Also shown are some of the major factors which affect the planned time intervals and costs estimated to complete these steps. Also given are the typically required time ranges for completion of the steps between each of the milestones. Variances in time ranges may be extensive and depend upon the major factors identified on the right-hand side of the figure. In the 1970s, due in large part to the proliferation of specialized information service organizations and the mass introduction of time-sharing systems which may require only the design and deployment of remote terminals within the core organization, the time ranges can be expected to contract. However, the basic steps and the cost and time factors are still valid.

A more detailed breakout of the basic steps which characterize the major activities between milestones and the cost and time factors unique to each activity are identified in Appendix I. This Appendix further breaks out these six steps into a total of sixty-two substeps and identifies forty-four time and cost related factors. Thus, the ISS acquisition and implementation phase can be an extremely complex but structurable management control and scheduling effort which involves a variety of people inside and outside of the core organization. If planning is unrealistic and not well thought through, costly and disruptive ripple effects will occur.

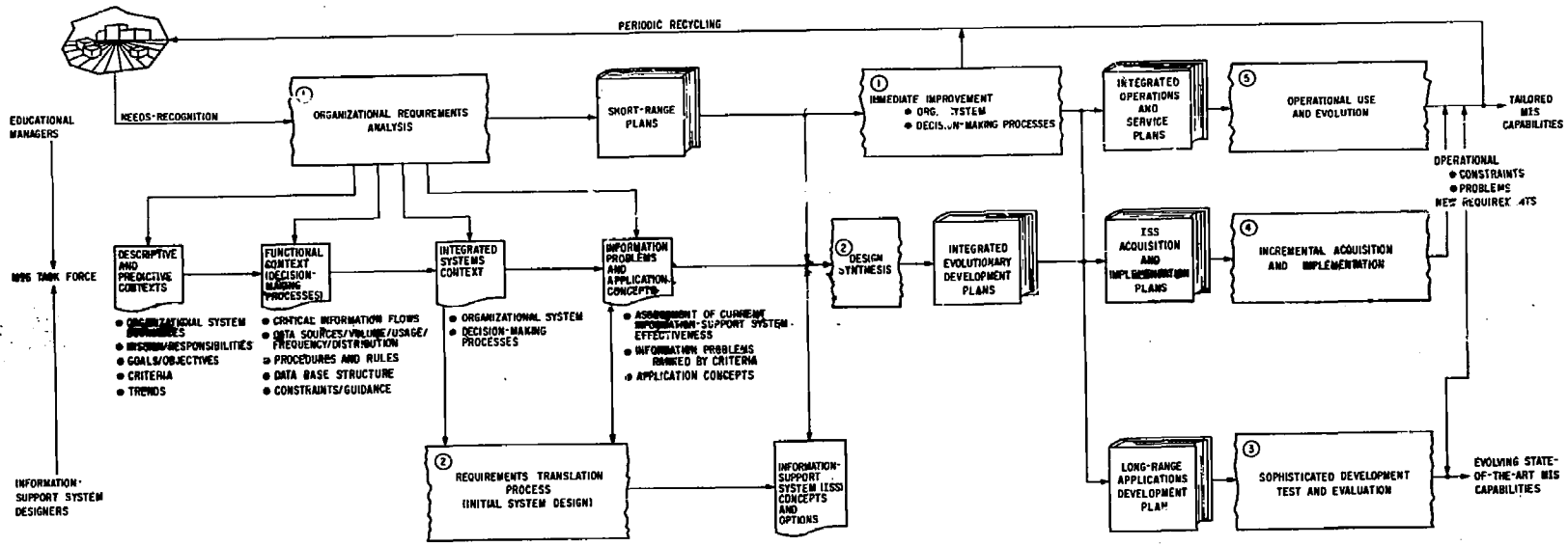
A major point of this discussion, notwithstanding the complexity of the ISS acquisition and implementation effort, is that the basic cause of management problems at this stage is fundamentally and critically related to the quality of the organizational requirements analysis and design efforts which have preceded it. In short, this is a big job but one which would be impossible to execute regardless of the skills of management if the right type of information from earlier analysis and design efforts is not available. A major purpose of this paper is to provide the educational manager with a more integrated and balanced perspective of this particular effort within the larger context of the other

types of efforts in order that he may be in a better position to understand and assess some of the major reasons for fragmented failure which have too frequently occurred due to a lack of understanding of the overall process.

After plans are developed and new or up-graded information-support capabilities have been installed, a number of unanticipated operational constraints, problems, and new information requirements usually result. During this transitional period, an evaluation should be made to reassess whether or not the newly-acquired capability fulfills the core organization's requirements and lives up to the expectations of outside support organizations as reflected in specifications, plans, and contracts. Because of the importance of this activity, guidance for making a post-implementation evaluation is presented in Appendix V.

EXECUTIVE INFORMATION SYSTEMS

A FRAMEWORK FOR THE EVOLUTIONARY DEVELOPMENT



Parts 1 and 2 of this paper have described basic types of efforts within the common framework which imparts a systems management perspective of what should take place to assure cost/effective MIS evolution. In highly summarized form, a flexible and adaptive process has been described which incorporates the painful lessons learned in the 1960s. For instance, the "lessons-learned" experience dictates that a much broader and substantive problem-finding analysis should precede detailed design and a much broader spectrum of interdisciplinary professionals and management personnel should at various times be brought into the MIS Task Force in order to avoid fragmented failure. This process will remain valid regardless of what computer power acquisition strategy is selected (see Appendix I) in the 1970s.

The framework has been designed, on the one hand, to avoid being too specialized and rigid, and, on the other, too general and ambigious in order to provide systems-management insight to the educational manager. It is also flexible enough to provide some initial guidance to management and design personnel who are interested in either a fast and comprehensive first iteration or a selective and more detailed analysis of a particular type of effort. In addition, the framework can be used regardless of what stage of manual computer-

based management information system development is confronting a particular organization. Finally, it should help the manager to decide upon a proper pace of evolution. This is largely a strategy problem centering upon the fact that the major tradeoffs should be understood better than they are by most managers.

Part 1 concentrated on developing an understanding of the current system, conceptual development of new organizational and management systems, identification of information problems, development of application areas for detailed design, and the specifications required for effective design synthesis. Part 2 concentrated on highlighting some of the major aspects of design synthesis and the integrated planning which leads to detailed development, acquisition, implementation, and evolutionary improvement of a Management Information System. As appropriate, reference has been made to the literature via Appendices I through V.

These efforts have covered a spectrum which encompasses: (1) recognition of needs, (2) development of systematic descriptive, predictive, and integrative contexts, (3) specific and evolving concepts concerning organizations, (4) management decision-making processes, and (5) the in-

formation-support system through the development of a set of plans which must be integrated in order to bring about the acquisition of new and evolving information-support capabilities without disastrously disrupting on-going operations. A process has been recommended which facilitates coordination of other internal and external organizational and system design efforts in order to reduce risk, time, and cost.

In closing, this paper has tried to provide the educational manager with a synopsis of the "lessons-learned" experiences of others by imbedding them in a framework for the evolutionary development of an Executive Information System.

EPILOGUE

The elaboration of communication and control systems, whether by the proliferation of special staffs, or by detailed downward delegation of the responsibility and authority for making decisions, or by decentralization, has been motivated by the need to find ways in which the human limitations in dealing with great volumes of information speedily and accurately can be overcome. Until the recent past, major advances in this quest have been organizational attempts to integrate people and work in such a way that some practical match could be attained between the data processing that had to be done and the available human capacities to do it.

In the attempts to solve this problem, two kinds of concessions have been made as a matter of course: first, less has been asked of the data than might have been; and, second, the answers to the questions asked have been accepted with suitable margins for human error. This compounded uncertainty has been accepted as a basis for operations, because to have demanded much more might have meant getting much less.

Many time-tested organizational procedures have evolved in response to precisely this continuing informational uncertainty, and their validation in practice rests on the fact that they serve to compensate for the continuous error in the system. To the extent that facilities for the handling of information improve, many of these compensatory procedures will become less meaningful and perhaps even deleterious. But habit, training, and emotional investment will make changes difficult. The lady who didn't approve of stained-glass windows defended her opinion by saying that she liked her "glass the way God made it." In the same way, many will feel that the threatened practices are not "temporary buildings" but rather the "true architecture."

Alex Bavelas, "Communication and Organization," Management Organization and the Computer, edited by George P. Shultz and Thomas L. Whisler, Glencoe, Illinois, The Free Press, 1960, p. 130.

Appendix I - Major Steps, Time and Cost Factors Associated with MIS Analysis, Design and Implementation

The major steps in the incremental acquisition and implementation of MIS operational capabilities, together with the key factors which influence the time and cost of completing these steps, are outlined in this Appendix. They should provide the manager who is unfamiliar with this complex but fairly well understood process with a basic management perspective of what is involved and what typically causes slippage, over-run, and mismatch problems. This Appendix draws extensively from a MITRE synthesis of the process (see Appendix II, Reference No. 34). It is most directly useful for those situations where an "in-house" computer facility is being planned by the local educational agency.

However, the explosive and diverse growth of the "software industry" (see Appendix II, Reference No. 25 for educational management implications) will extend the range of feasible computer power acquisition options that are available even to the smaller educational agencies (see Appendix II Reference Nos. 41, 59, and 63). A variety of equipment, software, application, and service contractual arrangements are becoming available, as implied by the classification below:

Hardware
- General purpose computers
- Special purpose computers
- Peripheral devices
  Supplies

Software
- Proprietary software systems
- Software consulting

Application
- Proprietary application systems
- Application consulting
- Control programming

Services
- Consulting
- Leasing companies
- Computer time sales
- Personnel recruiting

This proliferation of computer power acquisition options will in turn enable the local educational agency to evolve its MIS capabilities via several routes other than the acquisition of its own computer facility. (This is the option that is assumed in the supporting material to this Appendix.) For instance, the agency could: 1) only partially utilize its own computer initially and evolve by selling excess computer time and eventually develop its own service capability; 2) utilize outside service exclusively and evolve toward complete dependency on one or more outside firms; or 3) assume responsibility for doing its own problem finding (see Part I) and make use of an outside computer facility (e.g., state, town, university or industrial service bureau) initially and evolve toward acquisition of its own in-house computer facility or terminal.

Regardless of the specific MIS capabilities which may be required and the acquisition and evolution strategy chosen, a knowledge of the basic steps and likely problems as sketched in this Appendix will be useful.

This is so because the manager, whether directly (in-house option) or indirectly (outside options) acquiring MIS capabilities, is ultimately accountable for achieving a cost/effective evolution. The basic context presented should provide the manager with a handy check list and perspective for choosing a MIS evolution strategy that is tailored to his agency's needs and skills, time, and budget constraints.

PROBLEM DEFINITION AND GENERAL DESIGN

Major Steps and Their Time & Cost Determinants

3 - 24 Months

Major Steps

1. Establish automation project.
2. Appoint project task force.
3. Assign task responsibilities.
4. Formulate project objectives.
5. Establish project control schedules.
6. Establish reporting -- review and management -- control procedures.
7. Orient supervisors relative to project.
8. Survey information needs.
9. Define documentation standards.
10. Establish procedures for operational testing and acceptance of the new system.
11. Estimate general work load and data flow.
12. Prepare design specifications (tentative) for the new system.
13. Evaluate, debug, and redesign proposed system.
14. Determine what additional equipment and types of software are needed.
15. Evaluate in terms of financial and other criteria alternative means of acquiring the needed computer resources (lease vs. buy, etc.).
16. Obtain management approval for all aspects of the new system.

Time & Cost Determinants

1. Magnitude and complexity of the data-processing requirement.
2. Stability of this requirement.
3. The number and diversity of the administrative approvals needed.
4. Quality of documentation on existing system.
5. Quantity and quality of effort applied to the job.
6. Time actually available for developing and implementing the new system.

PROCUREMENT ACTION

Major Steps and Their Time & Cost Determinants

8 - 12 Months

Major Steps

1. Convert design specifications (both equipment and software) into procurement specifications.
2. Appoint source selection board.
3. Develop criteria for selecting contractors, i.e., translate design and procurement specifications into "benchmark" tests.
4. Prepare prospective list of bidders.
5. Prepare Requests for Proposals.
6. Issue Requests for Proposals.
7. Hold bidders conference.
8. Receive proposals.
9. Validate information contained in bidders' proposals.
10. Evaluate proposals and negotiate with "responsive" bidders.
11. Select contractor(s).
12. Secure appropriate approvals (technical and managerial) of the selection(s).
13. Announce Selection(s).
14. Consummate contract(s).

Time and Cost Determinants

1. Flexibility of procurement procedures.
2. Complexity of the procurement specification.
3. The type and extent of validation required.
4. The number or reviews and concurrences required.
5. The number of bidder proposals (and their complexity) to be evaluated.
6. The number of personnel participating in the procurement action.
7. The time available for the procurement action, i.e., the extent of management interest and pressure for a quick selection.

EQUIPMENT DELIVERY*

Major Steps and Their Time & Cost Determinants

1 - 24 Months

Major Steps

1. Receive order (sign contract).
2. Schedule production.
3. Receive materials and purchased parts.
4. Fabricate non-purchased components.
5. Fabricate and test sub-assemblies.
6. Assemble end products.
7. Inspect end products.
8. Package for shipment.
9. Ship.
10. Install.
11. Checkout.

Time & Cost Determinants

1. Degree of production standardization.
2. Previous manufacturing experience.
3. Current computer market conditions.
4. Production rate of the equipment ordered.
5. Contract delivery incentive conditions.
6. Government authorization for delivery priority.

*Many types of computer equipment may be needed-- a central processing unit, various types of input-output equipment, numerous off-line storage and peripheral devices, as well as "communications" equipment.

COMPUTER PROGRAMMING

Major Steps and Their Time & Cost Determinants

6 - 24 Months

Major Steps

1. Translate the general design specifications for computer programs so that the functions of and the approach to individual computer programs are clearly identified.
2. Establish operational standards to govern the system's programs.
3. Review and adapt any existing computer programs so that they can be used in the new data system.
4. Plan, design, code, test, and debug any additional computer programs needed for the new system.
5. Test the total set of computer programs to insure that they perform as an integrated computer program package.
6. Document all training and operating procedures for the developed computer programs.
7. Develop and implement procedures for making and documenting future changes to any aspect of the computer programming package.

Time & Cost Determinants

1. Magnitude of the programming task.
2. Complexity of the programming task.
3. Degree of modification vs. current programs.
4. Stability of the programming requirement during the period that programs are being developed.
5. Number of programmers assigned to the task.
6. Skill level of the programming task force.
7. Suitability of the major equipment available.
8. Programming aids available.
9. Project constraints.
10. Environmental conditions.
11. "Quality" of system-design documents used by programmers.
12. The "depth" of programming documentation required.

SITE PREPARATIONS

Major Steps and Their Time & Cost Determinants

2 - 18 Months

Major Steps

1. Draft site specifications (floor space, power, air conditioning, etc.).
2. Conduct site availability - adequacy study.
3. Negotiate contract(s) for necessary site augmentation.
4. Relocate people and equipment (if building is already occupied).
5. Complete major structural work (if needed).
6. Install (or modify) power and other utilities.
7. Install (or modify) air conditioning.
8. Construct raised floor (if necessary).
9. Complete minor structural work.
10. Check out all site preparations.
11. Move in equipment and people.

Time & Cost Determinants

1. The number of administrative approvals required for the site preparations.
2. The availability of a suitable building.
3. The type of building that must be obtained (if none is available).
4. The extent of structural alternations required if an existing building is to be modified.
5. The adequacy of environmental control systems.
6. The adequancy of the power plant and other utilities.

PERSONNEL TRAINING*

Major Steps and Their Time & Cost Determinants

3 - 12 Months

Major Steps

1. Study operations to be performed.
2. Analyze types and numbers of personnel required.
3. Write position descriptions.
4. Survey personnel availability to determine the number that can be transferred vs. the number that must be recruited.
5. Determine training requirements.
6. Establish training milestones.
7. Draft training program.
8. Develop and/or procure training aids and facilities (training equipment, building space, manuals, etc.).
9. Select and train instructors.
10. Trial test and refine training programs.
11. Recruit and select personnel to be trained.
12. Train personnel (operating, maintenance, and other).

Time & Cost Determinants

1. Market conditions for computer personnel.
2. Depth of the existing personnel "base".
3. Degree of newness of the new data system.
4. System complexity (equipment and computer programming).
5. Presence of built-in self-testing and self-diagnosis characteristics in the new system.

*Training must be provided both for those who will operate the Computer Center and for those who will use its services.

INSTALLATION-CONVERSION

Major Steps and Their Time & Cost Determinants

3 - 12 Months

Major Steps

1. Establish standard procedures, including procedures for effecting changes.
2. Start experimental operation of new system.
3. Debug new operations.
4. Refine system design
5. Make full system test.
6. Convert files.
7. Operate old and new system in parallel.
8. Phase out old system.

Time & Cost Determinants

1. Degree of interface between old and new system.
2. Efficiency with which prior, major tasks were accomplished.
3. Stability of data system specifications.
4. User-Developer-Producer-Installer Relationships.
5. Reliability of delivered Hardware-Software.
6. Capability of user's staff.
7. Amount and types of vendor support.
8. Criterion used to evaluate the installation.

APPENDIX II - BIBLIOGRAPHY

The growth of MIS literature parallels the growth of knowledge and crises surrounding the use of management information (see Reference No. 17). Furthermore, it is frequently authored by technical professionals who do not have a management perspective. The purpose of this Appendix is to provide educational managers with a selected reading list which is drawn from a wide range of sources, imparts a management perspective of Part II activities, and presents the more relevant items of interest in as clearly readable a style as possible.

Emphasis is given to the following topics as indicated below:

I. Introductory MIS-Related Concepts

1, 6, 8, 9, 15, 16, 17, 18, 22, 25, 28, 30, 32, 36, 38, 39, 42, 46, 50, 53, 56, 57, 60, 61, 62

II. Information Technology

3, 9, 25, 31, 32, 44, 51, 58, 59

III. Information Support System Design

4, 12, 14, 16, 21, 23, 24, 29, 31, 32, 33, 35, 37, 44, 48, 50, 54, 55

IV. MIS Implementation (Detailed Design and Procurement through Conversion - See Appendix I)

2, 12, 13, 14, 15, 19, 20, 21, 22, 23, 26, 27, 29, 33, 34, 35, 40, 41, 42, 43, 47, 48, 50, 52, 54, 55, 57

V. MIS Use and Evolution

1, 4, 5, 7, 10, 11, 15, 17, 23, 24, 25, 28, 30, 31, 33, 36, 37, 38, 41, 45, 46, 49, 51, 53, 54, 56, 58, 59, 60, 61, 62, 63, 64, 65

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APPENDIX III - GUIDELINES FOR SYSTEM DESIGN*

1. Make certain that organizational, functional, and application requirements are clearly stated and that a requirements change procedure exists and is rigorously adhered to.

2. Develop clear and explicit information support system and specific program design specifications.

3. Computer aid the function, e.g., budget planning itself, in relation to clarified organization objectives (see Part 1) not just its current procedures.

4. Integrate but avoid complexity in the design and planning of computer information support subsystems and operational capabilities.

5. Design a system that is modular, e.g., design each operational capability to provide specific system functions, so that they can be subsequently modified and replaced or even removed without the whole support system structure having to be redesigned.

6. Establish what the proper level of automation should be, keeping in mind political and economic, as well as technical feasibility.

*Adapted from Orlickey, J., The Successful Computer System: Its Planning Development and Management in a Business Enterprise, McGraw-Hill, 1969.

7. Avoid the need for an informal system.*

8. Provide for auxiliary system functions, such as an ability to simulate new capabilities, to diagnose data management problems, and to police the performance of unwarranted man/machine interactions.

9. Make the system as organization-independent as possible in order that organizational renewal can take place without substantial information-support system redesign.

10. Anticipate the system's impact on its environment, i.e., changes in individual management decision-making, decision-making processes, and organizational structure, insofar as possible that will result from its availability and use.

11. Provide for system growth via, for instance, development of an integrated system context (see Part 1), selection of general purpose software and choice of a suitable computer power acquisition strategy (see Appendix I).

12. Keep service to the management users uppermost in mind in contrast to being overly responsive to one type of user or to information support system professionals.

*An informal system is defined as a set of loose unwritten procedures followed by individuals in a gathering of information from informal sources, in the common-sense processing of all information, and in supplementing, working "around", and overriding the actions of the formal system in order to compensate for its crudeness, inflexibility, and imperfection. The formal system, of which the ISS is a part, represents what we thought, planned and forecast we would need; whereas the informal system establishes what we actually do need.

APPENDIX IV - GUIDELINES FOR INFORMATION-SUPPORT SYSTEMS PLANNING*

1. Make provisions in the Integrated Evolutionary Development Plans for taking small steps rapidly.

2. Develop alternative plans when significant contradictory trends are discerned in organizational objectives or technology.

3. Interface the systems plan (i.e., ISS Acquisition and Implementation Plan) with the organizational and the Long-range Application Development Plans, modifying them appropriately (see efforts 3, 4, and 5 in framework).

4. Document the system plan in a format intelligible to top management and arrange for periodic personal presentations (via Steering Committee).

5. Establish a formal mechanism for review and reiteration of the systems plan on a periodic basis, not less frequently than once a year.

6. Develop a system for tabulating and forecasting utilization of installed and on-order data processing equipment so that the useful life of such equipment can be reflected in the systems plan.

7. Fix the organizational responsibility for systems planning within the Steering Committee, MIS Task Force and information support system design team.

*Adapted from Head, R. V., "Planning for Real-Time Business Systems", Systems and Procedures Journal, July/August, 1967.

8. Rotate the assignment of in-house technical personnel to the MIS Task Force and/or organizational planning staff, enabling key people in the systems department,* to gain new insights and perspectives into system operations by exposure to the long-range planning process.

9. Budget for research and development (see effort 3 in framework) in order to permit first hand evaluation of new equipment and system techniques without the pressure of cost justification that is usually associated with the approval of new system projects or the acquisition of new equipment.

10. Set up a comparative systems "intelligence" activity to keep abreast of what other educational organizations are doing and planning, especially in regard to the development of other information support systems with which you may have to interface or which may provide you with needed augmentation capabilities more cheaply (see efforts 3 and 5 in framework).

*If a successful in-house evolutionary strategy is selected (see Appendix I), the MIS Task Force may at some point phase into a permanent MIS systems department.

APPENDIX V - GUIDELINES FOR POST-IMPLEMENTATION EVALUATION OF THE MANAGEMENT INFORMATION SYSTEM*

The following guidelines should be carried out by the Steering Committee after implementation of initial or follow-on operational capabilities in order to: (1) determine whether or not the new system adequately satisfies stated requirements; (2) establish whether or not the benefits derived from the new system justify the costs of instituting and running it and identify needed improvements; (3) provide a source of intelligence to be used in the areas of future organization planning, and systems planning and/or design.

Requirements/Capabilities Mismatch Assessment

1. Review context, plans, and specification documentation related to system requirements, constraints, and clarified objectives (see Part 1).

2. Investigate the degree of conformity with the system requirements as described in the user documentation (see Part 1) regarding, for instance, such aspects as flexibility, expandability, maintainability, inputs, outputs, files, processing, logical structure of operations, procedures and forms, equipment configuration, software specification, tasks, areas of responsibility, frequency of operation.

3. Discuss realization of requirements with user management and user personnel. (See also Guideline 11.)

*Parts adapted from Hartman, W., et al, Management Information Systems Handbook, McGraw-Hill, 1968, and Didis, S. K., "Value Analysis of Information Systems", Journal of Systems Management, November, 1969.

Cost/Benefit Analysis of ISS

4. Study the latest version of the MIS Task Force project budgets and cost and benefit reports.

5. Collect all data related to installation, development, and operational costs. This includes, for instance, equipment purchases or rental, contractor and in-house staff development costs, in-house computer facility and operations staff costs, housing, and other overheads.

6. Relate these actual costs to the anticipated or precalculated ones.

7. Assess actual system operations to verify that personnel and equipment to be phased out as parts of the previous system have, in fact, been eliminated.

8. Evaluate the impact other interfacing systems have on the system under study and appraise any existing or potential consequences resulting from this impact.

9. Analyze alternative methods and/or systems which could be used to accomplish stated objectives.

10. Compare the system's stated objectives to the objectives of other systems for the purpose of uncovering and either justifying or eliminating redundancies.

11. Investigate the actual benefits of the new system in relation to anticipated or precalculated benefits. This effort might involve a study to do the following:

    A. Redefine the original objectives of the ISS and evaluate how well the system accomplishes those objectives.

        (1) Have changing management goals, objectives, and problems been effectively translated into revised systems requirements and incorporated as modifications to the system?

(2) Have anticipated cost savings or other benefits been fully achieved?

(3) Have original system objectives been undesirably compromised in an attempt to satisfy other objectives the system was not designed to encompass?

(4) Does a favorable cost-versus-benefits trade-off exist?

B. Determine system output efficiency relative to management use.

(1) Is there added manual processing of data using computer output which would be more cost-effectively accomplished by expanding the system's programs?

(2) Is all system output used?

(3) Are meaningful data reduction and exception-reporting techniques employed to produce digestible, usable decision-oriented information?

(4) What is the impact of reductions on output reporting?

C. Assess the system's integrity.

(1) Do adequate procedures exist governing preparation and control of input?

(2) Does the system employ sufficient edits/audits of data?

(3) What is the general level of confidence placed in system output by the users?

(4) Is the precision, as well as the accuracy, of the system's results understood by the users?

D. Evaluate the system's processing efficiency.

(1) Are processing turn-around times satisfactory?

(2) Are processing delays frequent in occurrence?

(3) Are obsolete or unused data retained in system files and unnecessarily processed?

(4) Is processing logic straight-forward, easily understood, and properly documented? Are routines unnecessarily complicated? Are routines over-sophisticated?

(5) Do adequate data processing operations procedures exist?

12. Determine the extent to which non-measurable planned benefits have been achieved. These benefits are not necessarily related to the physical performance of the system, but rather to the way in which the user takes advantage of it. It should be noted that this analysis is not usually a "desk" evaluation, since accounting records are not structured for this purpose. It may very well require special analysis and field-collection of data in order to determine the extent to which these other benefits have been achieved.

13. If the new system realized benefits other than those anticipated, make a point of stating them.

Deviation Assessment (Organizational Problem Finding)

14. Check if stipulated organizational changes are complete (see Part 1 and Short-Range Plans in framework) and that everybody is accomplishing tasks and procedures according to expectations.

15. Explain all deviations detected and specify their significance. Political problems, as indicated by lower staff morale, higher turnover, etc., and technical problems should be included, as well as the economic problems covered above.

Follow-up Action

16. Summarize the post-implementation evaluation results under the following headings:

    A. Utilization of General Design Requirements;
    B. Utilization of Information Requirements for Each Application Area;
    C. Installation, Development, and Operating Costs (actual and planned);
    D. Benefits, Measurable (actual and planned);
    E. Benefits Non-Measurable;
    F. Realization of Planned Organizational Changes and Identification of New Problem areas;
    G. Summary of Deviations, Problems and Corrective Action Recommended.

17. Develop a detailed work plan (see Guideline 16-G) for recycling through the framework as discussed in Part 1 and Part 2 in order to: correct deviations; accommodate unanticipated organizational "adaptation"; modify existing operational capabilities; and develop follow-on capabilities. This plan will involve updating by exception the context, plans and specification documentation. To the extent adequate documentation and management procedures were prepared during the initial implementation effort, the management, and costs involved in MIS evolution will be considerably reduced and the chances for successful evolutionary development will be enhanced immeasurably.