CALIFORNIA STATE UNIVERSITY, NORTHridge

MANAGEMENT CONTROL OF DECISION-MAKING
PROCESS IN HIGHER EDUCATION BY
APPLICATION OF SYSTEMS ANALYSIS
TO PROBLEM SOLVING

A thesis submitted in partial satisfaction of the require-
ments for the degree of Master of Arts in
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by
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- Formulate the Desired System
- Characteristics of Present System
- Identify Differences or Problems
- Identify Resources Constraints
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ABSTRACT

MANAGEMENT CONTROL OF DECISION-MAKING PROCESS IN HIGHER EDUCATION BY APPLICATION OF SYSTEMS ANALYSIS TO PROBLEM SOLVING

BY

Lawrence R. Walsh

Master of Arts in Education Administration - Supervision, Higher Education

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This paper discusses the need for and a method of obtaining change in the decision-making processes of higher educational institutions. Often, decisions are made intuitively and subjectively rather than objectively with facts. In the important art of decision-making there is a basic need for a technique to obtain facts and their interrelated data.

To develop the application of these facts, a brief discussion of management theory is presented and related to today's environment. Time, cost, and decision definition are associated.

To obtain improved decisions to problems, better definition of
the problem and possible solutions are required. Systems analysis technique is one means to this end.

Systems analysis defines the problem, determines the objectives to be achieved, notes the controllable and uncontrollable factors, and outlines the constraints of the solution. It also develops a synthesis of the solution, a model of the proposed solution, and simulates to determine alternatives. All solutions are then evaluated. One is chosen for implementation, and a feedback method developed for determining correction and modification.

Each systems analysis stage is examined and related to the whole.

A model for systems analysis decision-making is presented and analyzed as to its parts and their inter-workings and relationships. The implementation of this system analysis technique is summarized in a decision-making procedure manual using the "forget-me-not" method of supplying answers to pertinent questions.
PART I
THEORY

While systems analysis techniques have been developed for use in complex aerospace and Department of Defense projects, their use in other decision-making organizations such as state, city, and educational institutions has not been widespread.

This section will develop the management science theory as used today. The discussion will be directed to the development of cost effectiveness and cost benefit objectives.
CHAPTER I
Introduction

The days are past when education leaders can assume that they are respected, looked-up-to by society, and are above the day-to-day disturbances of living. Indeed, it seems that they are at the center of the disturbances. Education affects everyone - those receiving it, those giving it, those administrating it, those who are acting as agents for the public's taxes, and each individual who pays his taxes.

Each of these persons has a different viewpoint as to what is important, relevant, and necessary. Each person usually also has rather firm ideas and opinions as to what is not required or relevant in an education. For example, the so-called "quiet years" when only Joe McCarthy, student apathy mixed with seasonal mischievousness, or alumni athletic ambitions combined with educational atrophy stand in sharp contrast to our present times. Now, weathermen are not meteorologists, pigs are not of the bucolic life, young lords are not of the nobility, and panthers are not a beautiful animal species. (1)

Times are changing and education administration needs are also changing. There seem to be five kinds of administrators: those in transition, those in flight, those in desperation, those newly baptised, and those who are determined to meet the challenge by adopting new methods of operation.

One of the new methods of operation is the systems analysis technique. This process is called by various names - operations analysis, operations research and management science.

For our purpose, management science will be defined as a scientific approach to problem-solving for executive management. The concern in this paper will be with the intellectual dimension rather than the hardware (machine) dimension of technology.

The distinguishing characteristics of the management science approach are:

A primary focus on decision-making.
An appraisal resting on economic effectiveness criteria.
Reliance on a formal mathematical model.
Dependence on an electronic computer. (This is dependent upon the type of model being used and data manipulation required.)

An application of this approach involves:

1. Constructing mathematical, economic, or statistical descriptions of models of decision and control problems, to treat situations of complexity and uncertainty.

(2) American Association School Administrators, "Administrative Technology and The School Executive" (Washington, D.C., 20036, catalog No. 75-104955).

(2) Analyzing the relationships that determine the probable future consequences of decision choices, and devising appropriate measures of effectiveness in order to evaluate the relative merit of alternative actions.

(3) The application of these obtained data are the making of decisions. Decision analysis separates a large scale problem into its subparts which are easier to diagnose, manipulate, and thereby develop solutions.

In applying this scientific method it is well to keep in mind that the model is a theory and not reality. The test of reasonableness, including historical comparison, should be made. Also, the use of intuition, hunch, or art should not be excluded since these usually are unconscious decisions-making models of the individual representing his life-long experiences. This latter item is of particular importance. Because the resultant system must interact with human beings, a successful implementation of a management science system must apply behavior science as well as mathematical science. The implications and application of Maslow's behavior levels should be kept in the forefront of the decision-maker's thinking. (Figure 1 shows a comparison of the individual's needs to those of the organization's needs using Maslow's behavior levels. It is necessary to recognize and preserve

NOTE: This hierarchy placement will allow establishment of optimizing criteria, a basic need for quantitating model - building for decision making.

Comparison of Individual's needs with organization's needs using the Maslow levels. (4)

FIGURE 1
the individual's level of needs while determining the best possible solution to the organization's problems.)

This systematization approach to decision-making is a process of obtaining analyses of quantifiable variables. Prior to this process it is necessary to make a thorough qualitative analysis to identify the critical factors (or the presently accepted critical factors). This will identify what the principal decisions are, what the measures of effectiveness are among these choices, and what sorts of trade-offs among these measures are likely to ensue in a comparison of the alternatives. This resultant "feeling" will help considerably in gaining acceptance and implementing findings of the analysis. The factors making up this system are:

A clear statement of the problem and its elements. These include the controllable or decision variables, the uncontrollable variables, the restrictions or constraints on the variables, and the objective for defining a good or improved solution.

Construction of a model which helps put the complexities and possible uncertainties into a logical framework amenable to comprehensive analysis. It identifies the static and dynamic structural elements, and quantifies the interrelationships among these elements. A well built model makes a valid comparison among the alternatives and centers on three themes; emphasis on optimization, derivation of the analytic properties
of the model, and the recognition of the system interactions. The performance of the analysis, given the initial qualitative factors, the model with its comparison elements, is the formulation of the solution.

The implementation of the solution.

The updating of the model with the feedback information to make it more realistic to the situation as now known.

The final solution will consist of the most favorable set of values for the decision variables with some information as to the cost of deviating from these values.

While the methods and techniques can be defined, the application of the human mind and its unique thinking processes cannot be. In defining the types of human minds, L. D. Silvern in "The System Aspect" writes, "Human minds and thinking characteristics tend to fall into three main categories:

(a) Analysts - can examine a whole and break it down.

(b) Synthesists - can create unknown wholes by building up discrete and often unrelated parts.

(c) Knuckleheads."

Hopefully, this paper will be of use to the first two categories.

The development of change is more easily accomplished if it can be shown to be an extension of one's previous experiences. In Chapter II
the goal is to present the theory of the systems analysis technique in terms of the types of management and the management levels of decision-making. It is recognized that each type of management and level of management may reach a decision by a different method or route but all have many common elements. All types and levels can benefit by using the information developed by this analytical system. In addition, the elements of the systems analysis are examined, defined, and their interrelationships shown. A model of their operational relationship is developed.

In Chapter III a model for decision-making, using the system design analysis techniques, is presented for use in changing an existing system. The goal of this model is to preserve what is right with the existing system but to institute change and correction where necessary. Again the elements of the model are defined but here in terms of how they are used in a live situation rather than from a theoretical viewpoint. To illustrate the application of this technique in higher education a sample problem is solved in Chapter IV.

Chapter V is a checklist of questions for decision makers. If answers to these questions are found, and evaluated correctly, the decisions made or solutions used will lead to the correct answer for the problem in that particular time frame.

The ideas, methods, and implementation presented in this paper are summarized and conclusions made in Chapter VI.
CHAPTER II

Theory of management types, management level of decision-making, and elements of systems analysis technique for decision-making.

The particular model which is employed in reaching a decision is modified by the type of management employed. There is no one perfect theory of management. The theory used should be one that best suits the manager using it.

The five principal schools of management are: Scientific Management, Functionalism, Human Relations, Behaviorism, and Management Science. (5)

*Scientific Management* uses a closed system approach which ignores employees' needs and human relations. It does not consider the systems in which employees require problem solving ability. This school of management is exemplified by Taylor's time and motion studies as solutions to problems.

The *Functional school of management* covers the managerial processes of: Planning, Organizing, Staffing, Directing, and Controlling. Again, in this management technique the significance is placed on control of material, facilities and personnel. Social factors are considered to be personal and no concern of the organization. While more general than Scientific Management it largely ignores the inter-

human relations make a sharp distinction between the formal organization of employees into work groups to achieve organizational goals and the "informal organization" that develops spontaneously to meet the social and psychological needs of the employees. The employees are recognized as having needs which influence how the group functions. While this management school recognizes that part of the problem's solution was connected with the needs of the employee, these needs were carefully separated into those associated with the organization's work and those associated with the employee's external environment. Only those needs associated with the organization were considered.

Behaviorism is based on the operations of social systems. Many small systems (individuals and groups) make up a school or business organization (system). In turn, this system operates with many other systems to create a larger system, namely, an environment.

Management Science employs the use of models of artificial construction which isolate the significant variables in real-work decision-making situations so they may be analyzed, evaluated and quantified in systems terms. It is defined as "a frame of mind and a set of attitudes." It is designing the components of a system and making individual decisions within it in the light of the implications of these decisions for the system as a whole. Management Science emphasizes the decision-making function as the unifying theme of all
managers.

Each of these styles of management has patterns of management activities which include:

**Decision-Making** - deciding what is to be done, who is to do it, how it is to be done and where and when it is to be done.
**Planning** - determining the goals of the organizations and how they can best be done.
**Design** - creating the system to achieve the goals in the most advantageous fashion.
**Control** - steering and correcting the deviations from the desired performance.
**Adaptation** - modifying the system to meet external challenges and threats and to take advantage of opportunities provided by the environment.
**Leadership** - motivating the members of the group to achieve organization goals and to be flexible and responsive to unusual situations.

These patterns of management activities are present at all levels of management and with all types of decisions. The information system used by management needs to supply information which is pertinent and timely for all types of decisions i.e., strategical, tactical, and technical. (6)

Each of these strategical, tactical and technical types of decisions has some common goals and elements. They differ in their time base as to how information is evaluated.

**Strategical Decisions** (Planning Function) - These decisions are future oriented, require a great deal of planning, and have a large factor of uncertainty. Their purpose is to establish long range policies which affect the entire organization. Goals of the organization must be stated and a range of strategies developed to accomplish them.

**Tactical Decisions** (Planning and Controlling) - Decisions pertaining to short term activities and the allocation of resources for the attainment of objectives i.e., budgets, personnel or research and development. The uncertainty factor is specific, i.e., supplies may be delayed two weeks, and has a short time base.

**Technical Decisions** (Control) - These decisions are made to insure that specific tasks are implemented. That is, the school facilities are organized for the dedication of the new library. Uncertainty factor is almost nil and time frame is immediate.

All of these types of decisions require different kinds of information. This can be shown as follows:

**Strategic Information** -
  a. External information which is available from industry,
government, professional organizations, customer reactions (students) and estimates of available resources.

b. Predictive information obtained from determination of long-term trends.

c. Simulated information developed by answering questions of the "what-if" type.

**Tactical Information**

a. Descriptive information is obtained from historical files, what has been done before about this type of situation?

b. Performance information is an evaluation and summary of the current environment.

c. Predictive information for tactical purposes is evaluated only for short-term effects.

d. Simulated information again is characterized by "what-if" type of question but here the questions are concerned with the immediate future.

**Technical Information**

a. Descriptive information is historical in nature but emphasis is on the immediate use to control specific operation.

b. Performance information is an evaluation of the current condition of a specific operation for control purposes.

To use these informations most effectively various techniques can be employed which allow the information to be adapted to different purposes. These techniques are:
Management Science - uses models in which data are manipulated to obtain alternatives. Models developed reflect the needs of the management level of the decision maker.

Filtering - uses technique where information is provided in a manner pertinent to type and level of decision-making. Can be used to summarize, manipulate, sort, and analyze information to a specific use.

Interrogative - allows different users to use a common base of information for different levels of decisions. Each can go as deep as necessary for his specific need.

Exception - uses technique of error detection, i.e., information which deviates from an established norm is brought to the attention of the decision-maker. He controls the corrective and preventive operations.

External - uses information obtained from the environment which affects tactical or strategical decisions. It is provided in filtered forms to those who require this type of information.

The numerous types of decisions, the multiple factors affecting various operations and the variety of information needed at different operational stages present a decision-maker with his own variety of the Gordian knot. To separate the problem into its separate facts on an evaluated priority basis, systems analysis may be used. This technique breaks down large decision areas into smaller decision areas. These smaller areas are constrained (namely, boundaries are defined), evaluated, and can have solutions develop-
ed which meet the requirements of the overall problems in its defined state.

Each of these areas is defined as to content and depth, and is related with the other areas of the overall problem.

The systems analysis process can be represented by Figure 2.

The elements of this technique are: (7)

1. **Problem Formulation** - Development of an accurate description of present situation showing disparity which must be eliminated.

2. **Define Objectives** - The objectives provide the structural framework and overall goals for the system analysis. The objectives establish limits and guide lines for the remaining basic acts of this technique. They also establish a priority listing or ranking of objectives in terms of importance to solving the problem.

3. **Select Alternatives** - All possible alternatives need to be considered even though some may be thought inferior. Alternatives are competing systems for accomplishing objectives with somewhat different constraints, fiscal and physical resources. Since any of these factors may change during the decision-making period alternatives need to be evaluated.

4. Define Assumptions - Assumptions concern the larger environment factors in which the alternative system will work. Facts defining these factors are best, but where they are not known assumptions are needed. They can be tested and ranked when the model is built. Modifying assumptions and observing model output is the usual manner of test. Ranking of assumptions is equated with their impact in the most desirable objectives.

5. Define Constraints - The definition of constraints needs to be as complete as possible to give the best presentation of the situation and prevent the making of inappropriate evaluations. Constraint elements to be considered include: money, top management's view of scientific management, politics, administration styles, psychological, sociological and technical impacts.

6. Define Criteria - Criteria are the rules and standards by which the alternatives are ranked. They must be relevant to the problem area, include consideration of all major effects relative to the objectives and, hopefully, be adaptable to meaningful quantification.

7. Data Collection - All pertinent data of each alternative to be collected in a useable format.

8. Build Model - The need for a model depends upon the complexity of the system and the number of alternatives. While a model may seem complex it should be kept in mind
that this model may be (with alterations) used again for another problem. In fact, it can be made in computer program form and used like a recording.

9. Test Assumption - As stated in (4) above, when alternatives are developed according to the assumptions made the assumptions can be modified and the effect on the model checked. By ranking assumptions in order of impact on desirable objectives alternatives for this factor can be chosen and ranked.

10. Evaluate Alternatives - Two methods are most usually used:
   a) Cost Effectiveness Analysis - (compares the cost of implementation of each alternative with its real benefit - not in dollar terms).
   b) Cost Benefit Analysis - (compares cost of implementation with the dollar value of the benefits accrued from implementation).

11. Check Solution Acceptability - Reconsider all the above elements, including all the new data obtained by moving through this analysis. A better set of evaluations, perhaps new alternatives, will be obtained. This output then must be checked to see that the solution meets the requirements and is acceptable.

If the solution is acceptable the next step is implementation. However, if the solution for any reason is not acceptable the reason for the non-acceptability must be
12. **Criteria Restriction Re-examination** - Since the solution was not acceptable for the conditions imposed, these conditions (restrictions) need to be examined for validity. It may be possible to change the limits of the restrictions and have the acceptable solution. If so, again the solution is implemented. If not, the problem must be re-examined.

13. **Re-examine Problem** - With the accumulated data of the analysis a better statement or definition of the problem should be made. This is followed by an iterative process of the analysis (1-12) until an acceptable solution is achieved.

14. **Implementation** - The acceptable solution is known but it needs to be implemented. Here the systems analysis technique can again be used, only this time the objective will be to simulate the implementation. By simulation the probable and possible areas of trouble can be determined. Solutions or alternatives for these areas can be determined so that the system in actual implementation can move smoothly into operation.

In observing Figure 2 the line from the "Re-examine Problem" area is the repeat cycle operation. The restrictions on this iterative process are usually time and money. The decision-maker may be forced to accept a less than optimum alternative plan because of the constraints present. A time deadline may be operative or the
SYSTEM ANALYSIS CYCLE AND RECYCLE

Figure 2
cost of the analysis may no longer be cost effective. These types of constraints upon the recycle process can be represented by a contracting helix as shown in Figure 3.

The spiral model represents graphically the processes used to arrive at a solution using the iterative cycles of systems analysis. The axis line is actually three lines representing the solutions as time and cost. Time and cost both increase to the right side while the solution approaches the point of perfection in this direction. The developed solution is that point on the solution axis where the iterative cycle is stopped. This point (A) by extension to (B) and (C) determines the uncertainty factor of the solution and the cost factor of the analysis.
Increasing Time

Decreasing Uncertainty

Iterative Process

Solution Axis

Time Axis

Cost Axis

Increasing Time and Cost

SPIRAL MODEL OF PROBLEM SOLVING

FIGURE 3
CHAPTER III
Model For System Design Of Decision-Making

The systems analysis process for problem solving is very similar for all problems but as stated earlier may vary depending upon the user's management beliefs. The model for a particular problem may vary considerably depending on the problem's unique characteristics. In this chapter a model for the problem of decision-making is explored.

System design is a creative process focusing on goal-oriented change. The role of the creator is to devise a course of action for improving an existing system or build a new system within the constraints of allowable resources.

The objective is to design a system that will furnish information at the right time, at reasonable (affordable) cost, in the form suited to the requirements of the users. To do this the creator must have considerable knowledge of all factors affecting the system development effort. The following aspects must be analyzed and integrated into a cohesive system.

- **Decision-Making Environment** - Define management area as strategic planning, tactical control or operational (technical) control.
- **Information Requirements** - Determine the type, accuracy, volume, form and timelines of data needed for the decision elements of the problem.

**System Objectives** - Determine needs and delineate the capabilities required of the information system within the constraints (specifications) of the system's scope.

**System Scope** - Determine boundaries that define and limit the system, its uses, geographic areas serviced, types of inputs and outputs required for interface with users.

**Time Frame** - Determines the time allotted for system development. The affect of time constraints and the implications of sacrificing more important long-range objectives for lesser short-term improvements need to be considered.

**Resource Constraints** - Develop a list of limiting factors affecting the decisions. This includes a realistic appraisal of the time, funds, equipment and skilled personnel available for system development.

**Computer Technology** - Consider the advantages and disadvantages of computer usage. What is needed is knowledge of existing hardware and software that can be employed in various combinations to produce viable system configuration alternatives. Present usage versus advantage and cost of change need to be detailed.

**Interface Requirements** - Determine the type, status and characteristics of the existing system inputs and outputs. Plan the necessary steps so the system under development will match these conditions. If existing system is to be replaced then change must be planned.

**Change** - Develop list of those items where anticipation of growth
or re-direction of system caused by conditions arising in external environment or within the system itself may require modification to the system.

Combining these myriad variables into a system requires that the creator have an organized procedure for evaluating and incorporating them into a responsive structure. The procedure or model permits the creator to introduce order into the process and provide a framework and terminology which serves as an effective means of communication.

The design of the information system model requires an examination and formulation of the factors, relevant variables, and activities of the system. Briefly these are, in order of priority:

**Formulate the Desired System** - To formulate a system a determination of the user information requirements into a set of system objectives must be made. These objectives constitute the performance criteria and general specifications for the design of the system. This activity necessitates the understanding of the environment, problems and responsibility of the various user groups, their decision-making process and the kind of information these processes require. The obtaining of inputs, ideas, concepts from users is very important for systems acceptance.

**Characteristics of Present System** - To use the maximum amount of the present system that system must be analyzed. This analysis process will provide insights into the reasons for the new or
changing system. It will also insure that the good portions of present system will not be discarded with the bad. It will highlight the differences.

Normative Measures - To eliminate subjective judgments to the maximum extent an assignment of quantitative values to system performance criteria must be made. These values will be the standards for evaluation of alternatives.

Known Problems - One way to try out the new formulation is to use it to explore known problems. The developing of alternatives for their solution and comparison with system objectives criteria may indicate existing system characteristics which will be constraints to the new system.

Consideration of Alternatives - To compare the developed alternatives a decision rule and evaluation technique must be established. Each alternative must have a cost/effectiveness or some other standard measure of status. This will allow a preferred ranking of choices to be developed. From this ranking the most rational, dependable alternative is chosen and a detailed design specification developed. It is recognized that because of material or time constraints, the best solution may not be possible. The purpose of this system process is to insure that the best possible solution is found.

Implementation Factors - The placing of a system "on-line" requires certain steps; (a) development and/or acquisition of hardware and software, (b) full system debugging, (c) refinement of
design, (d) full system test, (e) conversion of files, (f) operation of new and old systems in parallel while phasing out of old system.

Each of these steps can and will bring forth its peculiar problems. Delivery of new hardware, i.e., calculators for business office accounting, a desk top computer for school of engineering, etc. may be delayed and alternative choices may be necessary. If computer software development for administrative information is required the costs may be out of line with submitted estimates and another approach may be necessary, one which meets the cost constraint. Once the system is started in operation, the need for changes and elimination of 'bugs' to insure smooth interfacing and understanding with the personnel involved is necessary. In most cases, if all factors have been evaluated, these will be of minor nature and are expected. In fact, this may be the most cost-effective method of handling these types of problems.

This start-up period is also a selling time for the new system. Its obvious advantages are evident to the user and his suggestions for changes and corrections should be considered seriously and adopted wherever possible. It is important for the success of the new system that the user identify himself with its conception and successful operation.

**Formal System Evaluation** - A monitoring of the system operation results and the user's feedback provides the information needed
by the designer to evaluate the system and to form the basis for its improvement or redirection. It allows him to examine his system objectives, his normative measures used, and to re-evaluate his alternatives.

After this "break-in" period the formal scheduled system evaluation should be held. This is the time when actual and predicted values can be examined in the framework of the system objectives. This formal evaluation may have four outcomes; (a) buy the system as it now exists, (b) buy the system with changes as specified, (c) reject the system and return to previous system, (d) return to previous system with specified changes.

The virtue of the system design model is that it provides a systematic explicit and efficient way to focus required judgment and intuition (art). By introducing a precise framework and terminology it serves as an effective means of communications allowing all affected personnel to contribute in a well defined context and in proper relation to each other. The concept also incorporates the means for positive or negative informational feedback. This type of information is necessary to guide system design participants in the revision of their earlier judgments. These features of the model are essential to its role in providing a route from concept to reality. See Figure 4. Because of the necessarily limited view and time bracket of this system it should be recognized that not all problems arising from external factors can be anticipated. These factors include such items as legislation changes, emergencies and a shift in
FIGURE 4
*Analysis of information requirements and development of system objectives. (0 - 10 Sequence of Activities)
objectives (priorities). When these arise and are evaluated as being of sufficient significances the decision points of the system which are affected will need to be revised.

An examination of each level of the model and the type of questions for which answers are required is presented.

Environmental Conditions - The objective here is to understand how decisions are made and what information is required at each step of the process i.e., to understand the problem structure and at each level user's thoughts and needs must be solicited and considered. (The decision-making organization may be quite different from the formal organization chart.) What decisions the user makes must be determined, as well as the information he needs and his means of evaluation. Questions to be considered:

(1) What are the critical decisions or problems which require specific information support?
(2) What are the processes by which these decisions are made?
(3) What information is required in making these decisions?

Formulate the Desired System - Development of system objectives and information requirements are the things to be achieved. System objectives are evaluated as to management level with the first level being the highest priority. These are to be as specific as possible and must be understood by the users. Objectives defined in detail and accepted by users will avoid later misunderstandings. Objectives need to be defined as to what functions
the system is to perform. Descriptive statements of these functions using flow charts or other means of expressing the system requirements should be detailed. These objectives also provide the basis for determining performance criteria which serve as guide posts throughout the creative process. The specifications or criteria focus on key aspects of the system (highest ranking objectives) important to the users. They answer basic questions of what capabilities and characteristics are to be incorporated. To complete these criteria answers to the following type questions need to be available:

1. What source data is needed?
2. How timely must the data be?
3. What degree of accuracy is required?
4. How frequently must the data be processed?
5. How quickly must the data be processed?
6. Are calculations, if needed, simple or complex manipulation of data?
7. In what form are data to be presented?
8. How long a time lag is permitted between end of processing and reporting?

Characteristics of Present System - To be able to change, improve or replace an existing system it is first necessary to determine the system operation, the demands made on it, and its reactions to these demands. This will form a basis for the new system and its implementation. One method of forming this basis is to con-
Consider the use of the "Black Box" concept. This concept excludes consideration of operations internal to the "Black Box." Consideration is given only to external factors i.e., inputs and outputs and their relationships to time, need, and associated personnel. Thus, inputs (which are processed), source data and outputs (end products or reports used for decision-making or planning) are defined. Inputs are described as to their need, source, reliability, timeliness and frequency of collection. Outputs are described as to data contents, pertinence to objectives, their organization, preparation cycle, who are the users and how the outputs are used.

Identify Differences or Problems - The identification of differences between the new system and the current system should highlight the problems for which solutions are needed and the improvements desired. This understanding may also develop a checklist of tentative improvements. Some of these improvements will be capable of incorporation into the existing system. Whether they should or not depends upon their compatibility with the long-range objectives of the new system. If they are not compatible then they become a false economy. Those that are incorporated into the existing system provide an immediate feedback source to both systems.

This problem and difference identification operation insures that:
1. No important areas are overlooked.
2. Deficiencies of current system are identified and compatible
systems improvements incorporated.

3. The new system has some immediate feedback for design evaluation purposes.

Identify Resources Constraints - To develop a new system that is workable for the user, a realistic appraisal of each resource constraint involved in the system is needed. These items include: time for system development, funds, equipment, facilities, and skilled personnel. Combined, these items are the environment with which the system must interface. To develop an appreciation of how, where, what and when these factors will affect the system they can be structured into system functions and their input estimated. For example, if six months is the overall time limit for system development then a breakdown of estimated time needed for each system step is necessary for development allotment. These constraints can then be used with objectives and desired values to establish a system specification. This system specification with a value ranking system establishes a criteria for evaluating alternative system configurations. The criteria must have dimensions (magnitude) to become a performance measure to weigh achievement against cost. This establishes a decision rule for evaluation of alternatives.

Develop Design Alternatives - All possible solutions (even those not believed suitable) must be explored and evaluated against the standard (specified) system. The same factors considered for

the standard need to be quantified for each alternative. The resource constraints must be considered for each alternative and any deviations noted.

**Evaluate Design Alternatives** — Each alternative must be evaluated against the objectives and a value set on how well it achieves these objectives. It must be carefully checked to make sure it meets the specified constraints. If not, the exceptions must be listed in case a different constraint value can be used by trading off a lower ranking objective. Ranking of alternatives is achieved by use of the decision rule.

**Select an Adequate Design** — The decision rule has determined those alternatives which meet the system requirements. This rule also establishes those alternatives in a ranking order with the lowest being the most desirable. What factor(s) should be taken into account to select the designs?

While it is the purpose of this analysis to provide the most rational choice it should be recognized that the more complex the system the more indefinite the evaluations and the more dependent the decision-maker is on variables he does not control. An optimum choice usually does not exist so a compromise must be made between cost and effectiveness. A good rule for choosing a design is to choose one which minimizes the consumption of resources and yet satisfies the normative measures. This is a measure of its cost/effectiveness.

**Develop Detail Design Specifications** — Once the selection of an
alternative is made the details of the selected design can be started. These details transform the normative objectives, desired values, and resource constraints of the alternative into a specified system. Specifications are then developed for the major components making up this alternative. In turn, each of these major items are broken down to basic elements whose specifications detail their requirement.

Implement the Design - The start of a new system can be and usually is done by use of simple typical problems. Those areas where data supplied have been insufficient or not understood become obstructions to the flow and generation of information. The decision-maker at this level is not making decisions. These areas require trouble-shooting to determine the cause of the stoppages, and what or how it can be corrected. This information is the first feedback of the new system and should be carefully analyzed for its informational content. The fault may not be the system but a human factor. Multiple operations of a similar nature can be used to determine the nature and extent of this type of problem. Corrective action can then be initiated. Where-ever possible the current system should be kept operational both for work output and ease of changeover for the users of systems. The advantages of the new systems will be quickly realized by the users and adopted for their immediate use. This then sets the stage for translational phase where the current (old) system is retired.
Monitoring Results - Even though extreme care has been taken with the design, all factors weighed and circumstances imagined with safeguards built-in, things will and can go wrong. Thus, results must be analyzed (good and bad) as well as accomplishments in terms of initial objectives. Any corrective actions required must then be identified. When the system is operational the formal evaluation procedure should be used to aid in discovery of system weaknesses, trends, "problems in the making," etc. so that corrective actions can be immediately initiated. The evaluation procedure should address the following:

1. Have changing objectives and problems been effectively translated into revised systems requirements and incorporated as modification to the systems?

2. Have anticipated benefits been 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-benefit trade-off exist?

5. Is all output of the system being used?

6. Are meaningful data reductions and exception reporting techniques being employed to produce digestible, useable, decision-oriented information?

7. Do adequate procedures exist governing preparation and control of input data?

8. What is the general level of confidence placed in system
output by users?

9. Is the precision, as well as the accuracy, of the system's results understood by the users?

10. Are obsolete and unused data retained in system files and unnecessarily processed?

11. Is the processing logic of system easily understood and straightforward?

As was stated in Chapter I this entire process evolves into the breaking up of large problems into sub-parts so that decisions can be made with smaller variables and fewer unknowns. It is similar to educational processes which are oriented towards acquiring skills at developing the ability to process information to make decisions. Some decisions, like the mathematician with his slide-rule, lend themselves to use of the computer and the processes are relatively simple. Where important variables cannot be isolated the process is more challenging and unique models representing composite functions must be developed.

System analysis implementation to problem solving is an analysis in that it consists of four parts:

1. Analysis - Performed on existing system information to determine its benefits and needs.

2. Synthesis - Performed to create a new system which better meets the needs.

3. Modeling - Constructed to predict effectiveness without the
implementation of the system.

4. Simulation - Performed to reveal alternative solutions.

To illustrate this system design to decision-making an example problem in higher education will be developed.
PART II

IMPLEMENTATION

This section of the thesis will develop the actual processes used in implementing the systems analysis decision-making technique. Chapter IV is an example of problem solving in higher education using this decision-making method. The implementation of this decision-making technique is summarized in Chapter V in a decision-making procedure manual. Chapter VI provides the summary and the conclusions for the use of this technique.
CHAPTER IV

Sample problem in higher education using systems analysis decision-making technique

Problem - A staff member position will be open in the History Department of Local University in Fall term 1974. Need to find a properly qualified candidate for this staff position.

Environmental Conditions - Local University is a medium size (10,000 students) new school. It is located in the suburbs of a very desirable metropolitan area. Its plant is in excellent condition. It has had good planning in its original conception and is capable of providing the services required. The History Department has a well balanced staff but because of Board of Trustee pressure it is planned to strengthen the area of American History.

The department chairman is a senior professor who will be retiring within five years.

The salary offered is competitive but limited by budget. There are special funds available, if required to provide additional compensation for an especially qualified individual.

Formulate the Desired System - The successful candidate for the position should be qualified as follows:

1. Academic Background - PhD degree preferred from highest ranking universities. It is desired that this person have a proven background of successful teaching with a specialty in American History, Colonial Period.
2. Administrative Ability - Since the department chairman will be retiring in the near future, a person capable of and/or of recognized ability to do this job would be desirable. Government service at this level would be a preferred experience.

3. Professional Standing - Candidate should be recognized as a competent scholar in his specialty. He should have published in his field, recognized as a competent researcher, and have articulate ability.

4. Personal Qualities - Since this person may be considered as a department chairman in near future age is a factor. An age bracket of 38-48 is preferred. Marital status is not a factor but, if married, then the marriage partner should be of helping quality - especially so in the requirement of this position outside the classroom. Health should be excellent since the demands of the position are taxing.

5. Salary - Person should have a good progressive salary growth record. Salary level is not a limiting factor in case of especially qualified individual. Salary is competitive to other good to excellent universities. Fringe benefits are also comparable.

Characteristics of Present System - The present professor has a PhD from University of California and has been teaching at college level for twelve years. He is leaving to complete his post doctorate studies on European History, Napoleonic era. He has had a very good record while at Local University and is
leaving with excellent references. He has excellent potential growth, only limited by his non-interest in administrative duties.

**Identify Differences or Problems**

a. PhD level degree required.

b. Person must be capable of being or developing into department chairman. Administration experience should be part of background.

c. Specialty must be in American History, preferably, Colonial History since department is only adequate in this area.

d. While the departing staff member is a man, the overall university staff is male dominant, therefore, by law considerable thought must be given to women and minority race candidates.

e. The legal requirement in (d) above will be something of a problem with the present department chairman. He does not believe a woman would be capable of doing his job.

f. Decision required in time for successful candidate to have sufficient time to resign from the present position.

**Identify Resources Constraints**

a. A budget has been developed for the cost of administration in filling this position. Approximately three trips, depending upon distance, and reasonable time periods at destination have been allotted. It is desirable to do as much preliminary data accumulation as pos-
sible via mail or telephone methods. Sufficient funds are also available to bring the most desirable candidate to the campus after off-campus interviews.

b. In the light of the present chairman's biases and that the successful candidate may be a member of the Dean's staff the off-campus interviews will be conducted by the Dean of Letters and Science School.

c. On-campus interviews must include the present chairman and the department committee and they will be privy to all correspondence. Their suggestions and recommendations will be solicited and considered.

d. Time to accomplish this operation is limited by the date the successful candidate must notify his present department of his resignation estimated date March 1, 1974.

Time allotment: (Latest possible dates - working backward in time) -

Resignation - 1 March 1974
Candidate Accepts - 22 February 1974
Candidate Chosen - 15 February 1974
On-campus Interviews Completion - 1 February 1974
Off-campus Interviews Completion - 15 January 1974
Criteria Development for Staff Position - 15 Dec. 1973

Develop Design Alternatives - a. First alternative - Candidate has PhD degree in History (not U.S. and not Colonial period). (Agrees to specialize in Colonial Period upon acceptance.)
Experience includes a minimum of 10 years teaching experience at college level. Candidate is articulate but has not been published. Salary growth has been good and present department will recommend.

b. Second alternative - Candidate has a PhD degree in American History. Experience includes both teaching at college level and government service doing historical research. Candidate has published his research via professional organ. Salary growth very good, recommendations available both from academic and government departments.

c. Third alternative - Candidate has PhD degree in U.S. History Colonial Period. Has had academic administrative experience as acting head of department during department head's leave. Candidate is recognized scholar as an author of books in his field and frequently is asked to keynote professional organization's convention. Salary growth good, recommendations are good.

Establish Normative Measures

<table>
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<tr>
<th>Item</th>
<th>Points</th>
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<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>PhD (Dependent on University ranking)</td>
<td>3 - 5</td>
<td>History</td>
<td>1</td>
</tr>
<tr>
<td>U.S. History</td>
<td>2</td>
<td>Colonial</td>
<td>4</td>
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<tr>
<td>Teaching Ability</td>
<td></td>
<td>Articulate</td>
<td>2</td>
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<tr>
<td>Student Repoire</td>
<td>3</td>
<td>Technique</td>
<td>2</td>
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<td>Articulate</td>
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<td>Administrative Ability</td>
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<td>Health</td>
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<td>Minority</td>
<td>2</td>
</tr>
<tr>
<td>Good</td>
<td>3</td>
<td>Race</td>
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<tr>
<td>Fair</td>
<td>2</td>
<td>Sex</td>
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<td>Bad</td>
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<tr>
<td>Salary</td>
<td></td>
<td>Minority</td>
<td>2</td>
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<tr>
<td>Good Growth</td>
<td>3</td>
<td>Preferred Age</td>
<td>3</td>
</tr>
<tr>
<td>Fair Growth</td>
<td>1</td>
<td>Younger Age</td>
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<td></td>
<td></td>
<td>Older Age</td>
<td>1</td>
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</tbody>
</table>

Select a Decision Role - Excluding the minority classification the minimum acceptable point total is 16. In the case where candidates have these minimum 16 the minority classification where applicable will be added.

Evaluate Design Alternatives -

a. Desired System   - 38 points + possible 4 additional

b. First Alternative - 16 points + possible 4 additional

c. Second Alternative - 26 points + possible 4 additional

d. Third Alternative - 30 points + possible 4 additional

Thus our design alternatives have given a point spread of 16 (minimum for our decision rule) to 30 which compares very well with our maximum point total of 38.

Select an Adequate Design - In this particular problem where so many variables are available the min-max values establish our target area. The goal should be to select a candidate with the highest possible ranking - all other factors, such as personality, being equal. Since the human interface is so extremely
important in this problem all subjective factors can not be eliminated.

**Develop Detail Design Specifications - Position of History**

Professor available Fall Term 1974. Academic qualifications are a minimum of a PhD, preferred specialty in U.S. History - Colonial Period, 10 years of teaching/administrative experience, professional standing established by writings, speaking and teaching recognition, should have a good salary growth record, be able to furnish recommendations as to his professional and personal character and be in good health.

Candidate should be able to state his career objectives and his plan for accomplishing them. Local University, approximately 10,000 students, is located in the suburbs of a very desirable metropolitan area. Academic, Professional, Art, Sport and individual activities are available year round because of the mild climate. Living costs are average for this type of area and excellent schools at lower levels are available.

The History Department is well balanced in specialties and staffed by recognized professionals. Individual growth is encouraged.

**Implement the Design** - The implementation of the design can take several routes. Usually, personnel acquisition has relied on what in the past has been successful. Since time is so short
in this problem personal contacts via telephone or mail for possible candidate names would seem to be in order. One difficulty with this method is the "in-grown" possibility. Also, it is possible to miss an outstanding candidate because of a personal consideration i.e., personality clash, or professional jealousy or competition. Whenever time permits, the widest possible search should be made. The interview procedures and forms need to be developed so that all necessary items will be discussed; also, that each candidate will be responding to the same questions, as much as possible, thus eliminating any unknown biases. Without this standardization the ranking of the candidate will be very subjective - precisely what is not wanted. Two interview forms and procedures need to be developed, one for the Dean's interview off-campus and the other for the more detailed on-campus interview. If they are not already established, procedures as to who makes an offer and what can be offered, etc. need to be established. All such conversations should be immediately confirmed in writing to the candidate.

Monitor the Results - Some graphic chart showing the elements of the system, their status, and results will need to be developed. This will insure that the ball is not dropped or that someone thought someone else was taking care of the problem. It will also act as a PERT chart if a plot of the activities with their time date limitations is shown. In addition, with this monitor the quantity and quality of the
efforts can be followed. These results will tell if the system is working and, if not, where it will need changing.
CHAPTER V

Implementation of Systems Analysis Techniques

In a Decision-Making (Problem Solving) Procedure Manual

The implementation of the Systems analysis procedure is or should be a personal adoption which suits the situation (problem) and the individual characteristics of the person applying the system. The following is thus offered as a guide and not a rigid structure to be followed. Different environments and different individuals will call for expansion of some areas, the omission of others, and possibly addition of new items which are special to the particular problem and the user's needs. Since this procedure manual is to be a reminder of "forget-me-not" items it will be presented in a succinct fashion with the user supplying the remainder of the question or statement to fit the particular situation. The order will be similar to that shown in the model in Chapter 3.

(1) Define the problem.
   a) What needs to be achieved?
   b) Do these needs fit the goals of the organization?
   c) How does the present operation meet or not meet this need?
   d) Determine scope and establish boundaries.

(2) Develop objectives needed to solve the problem.
   a) Establish a priority ranking for objectives.
b) Establish a time organization for these objectives.

c) Quantify the elements where possible. (Use flow charts, PERT (Planning Evaluation Review Techniques) or PPBS (Program Planning Budgeting System) type to provide graphic visual aids.)

d) Are these objectives acceptable to the users?

(3) Formulate Solution (Standard)

a) Does it supply what is needed?

b) What does it require to function in way of funds, personnel, skills, legislation, approvals, time span, equipment, facilities and organization structure?

c) Establish a value performance measure.

d) Does the solution pose problems for the users?

(4) Develop alternative solutions.

a) Is all the information available for each alternative to be considered for the standard solution?

b) What special conditions are required (if any) for each of these solutions?

(5) Define assumptions and constraints.

a) What basis or premise has been used to determine the proposed solutions?

b) Have all items for each solution been considered

and normalized? Such items as time, funds, equipment, skilled personnel, environmental factors (government and physical) and user's needs.

c) Do interfaces exist which may pose problems for implementation?

(6) Definition of criteria.

a) Are all the factors that are required available?
b) Are these factors listed in order of priority as determined by the system objectives?
c) Have magnitudes been developed wherever possible for these factors?

(7) Collection of data.

a) Has it been determined what data, their form and accuracy are required to specify each of the stages of this system?
b) What differences are required by the alternatives?
c) Are these differences significant in regard to the constraints for this system?
d) Are there alternative sources of data which can be used as verification?

(8) Use of model.

a) Is the system sufficiently complex that a model is justified?
b) Have all the significant factors been used as to their priority, information and magnitude in the model?
c) Have PERT diagrams been developed for the normative system and the differences noted for the alternatives?

d) Has the model been examined for possible additional alternatives?

e) Has a FPBS cycle of activities been performed using the model and each of the proposed solutions? (see Figure 5).

(9) Evaluation of Alternatives.

a) Has a cost/effectiveness analysis been done on each of the solutions and the differences noted?

b) Is there a list of additional benefits (negative and positive) for each solution — the type which do not lend themselves to cost evaluation?

c) Have these magnitudes developed in cost/effectiveness been combined with the ranking of the objectives to give a composite rating of achievement?

d) Has a solution acceptability check been done?

e) Are all the constraints met or if not, is it possible to trade off a lower priority or lesser benefit for greater flexibility?

f) Are the criteria being met and if not, can the specifications be changed without endangering the objectives?

(10) Re-examination.

a) In the process of analysis have changes developed in
PLANNING
a) Clarifying goals;
b) Specifying long and short range goals;
c) Formulating a future course of action

PROGRAMMING
a) Generating alternative approaches to goals;
b) Developing operational plans;
c) Clustering activities related to objectives

BUDGETING
a) Translating programs into fiscal and non-fiscal requirements;
b) Programmatic classification of planned expenditures

ANALYZING
a) Specifying major assumptions, constraints, and uncertainties for each alternative;
b) Determining cost-utility of alternatives

EVALUATING
Reviewing outcomes and relating each to prior expectations.

DECIDING
Determining the optimum course of action or alternative for each action.

RECYCLING
Feeding evaluative judgments into the system to begin a modified PPBS cycle.

FIGURE 5
the objectives and goals?
b) Are the alternatives still acceptable and feasible?
c) Are there new constraints, criteria, or data sources which affect any of the solutions?

(11) Choosing a System.

a) Does the system chosen meet the objectives and goals within the constraints of the environment?
b) In the case of multiple solutions which most completely meets the higher ranking objectives?
c) Are there difficulties in implementing the solutions?
d) Does any solution, other factors being equal, present easier interfaces?
e) Have the users expressed or implied a choice of solutions?

(12) Implementing the System.

a) What interfaces must be considered and solutions for them developed?
b) Has the nature of the system, its objectives, goals, and benefits been clarified to all concerned groups or individuals?
c) Has the feedback from the initial communications with interested and interfacing organizations been incorporated or justification developed for not incorporating it into the system?
d) Does the PERT diagram include communication mile-
stones?
e) Is there a feedback loop implemented so that system "bugs" may be quickly corrected?
f) Have human factors, human interactions, and reactions been considered?

(13) Monitoring and Evaluation.
a) Is there a realistic evaluation of all results (good and bad)?
b) Have the objectives and goals been met?
c) What methods have been set up to alert the operator to the need for corrective actions? How are short-term/long-term factors handled?
d) Are there unnecessary operations or data collections being done?
e) Are additional data needed or are there other types of system defects requiring system modifications?
f) Do all stages of the system have data, procedures, and specifications needed to correctly operate?
CHAPTER VI
Summary and Conclusion

The concept of systems analysis applied to decision-making in higher education has been explored and illustrated. The elements of this system were examined, defined, and applied in an example problem. The idea of using magnitudes as determined by a normative process based on factual data rather than subjective methods has been discussed.

While this may seem to be a turn-the-crank-and-out-pops-the-decision type of approach to decision-making, it should be emphasized that systems analysis is a scientific method to the study of alternatives in a problem, quantifying them, and arriving at an optional solution in terms of the defined goals. It does not make decisions but provides quantitative data so that the decision-maker can do a better job.

For example, in the area of political decisions this method can be used to gather data. It then becomes a matter of communicating the results of this study to the concerned individuals. Facts, supported by study, weigh heavily against opinions which are unsupported. The systems analysis use of models is very comparative to the educational process. The educational process is oriented towards acquiring information to make decisions. The additional factor in systems analysis is the organization of the data in a form which clarifies the solution in terms of the goal desired. While it may seem that by
applying the iterative process again and again a better solution could be obtained, the Heisenberg Principle (11) operates here. This physics theory states:

There is a limit to the degree of precision which is possible in physical measurements, beyond which, the thing being measured begins to interact with and becomes involved in the measurement.

It is necessary to recognize that in all decision-making, no matter what method used, there remains an uncertainty element. How small we can make this uncertainty depends on our diligence and creativity.

To play a game, it is necessary to know the rules; to make a decision it is necessary to know the facts. To make better decisions requires practice at making decisions.

Selected Bibliography

Books


Selected Bibliography
Dissertations


