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SOME THEORIES AND CONCEPTS CONCERNING
A SYSTEMS APPROACH TO MANAGEMENT

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Some Theories and Concepts Concerning a Systems Approach to Management

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There is no need for management in a static world of perfect knowledge and certainty, but we do not live in such a world. We do live in a dynamic and uncertain post-industrial era. The accumulated knowledge base and continuing research offer much data about reality, and the risks managers face. It is a world where learning about the alternatives and predicting the consequences of their implementation is critical to creative management. It is a complex world of high technology. It is a world where an organized approach to problem definition and problem solving is useful.

A systems approach is such an approach. This paper provides an overview of the theories and concepts which outline a systems approach to management, management information systems (MIS) and management control systems. Systems concepts, information concepts, and control concepts are discussed. The paper provides definition and clarification to terms found in the literature on these topics. Then a discussion on the basic approach to designing a MIS follows. The last section of the paper illustrates the role of computer decision support systems as a sub-set which is gaining wide recognition in business circles today.

The system approach to management requires an identification and understanding of the basic concepts involved. This section deals with the conceptual basis underlying management information systems (MIS) and control system concepts.

Contribution to Exp. Station Project 14-036, Management Information Systems for Minnesota Farm Firms,

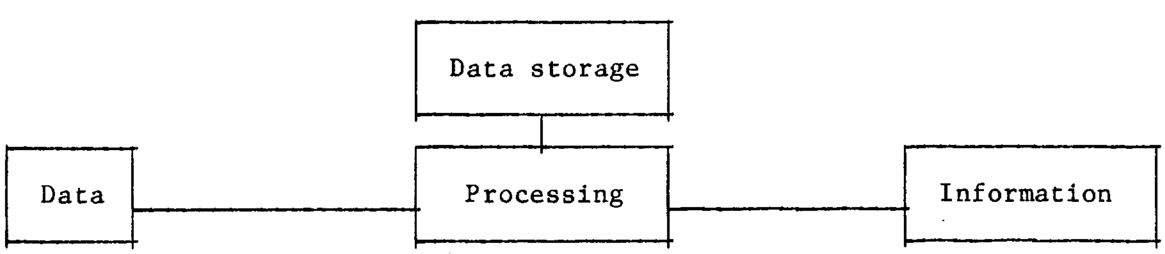
I. INFORMATION CONCEPTS:

"Information" is an imprecise term as it is commonly used. However in the decision sciences, underlying the use of the term "information" as in "information systems" are several ideas: information adds to a representation, it has surprise value, or it tells something the receiver did not know or could not predict. In a world of uncertainty, information reduces uncertainty.[1/]

Definition:

There are several definitions of information in the decision and information sciences. A useful one is the following: "Information is data that has been processed into a form that is meaningful to the recipient and is of real or perceived value in current or prospective decisions"[1/] (G. B. Davis)

The relation of data to information is defined as that of raw material to a finished product. More precisely, the processing system processes data in relatively unstructured form into more usable data that is likely to have information content to the intended recipient. The schematic below illustrates how data can be structured in ways to inhance its potential informational content.



Just as the finished product from one manufacturing division may be the raw material for another, information for one manager may be deemed to be mere data to another. Because of this relation data has often been declared to be information to another person when in fact it may not be.

Data, the raw material of information, is defined as groups of nonrandom symbols which represent quantities, actions, things, etc. Data can be organized for processing purposes into data structures, file structures, and data bases.

Data can be restructured or otherwise processed according to the processors' perceptions of what will enhance its potential informational content another. But ultimately it up to the other person, the receiver of a message from the processor to actually determine whether it also contain information in the MIS context.

Information, in the information sense, may have several attributes: true or false, new, corrective, confirmatory, or incremental. Thus information is associated with decision making and for this reason information can be considered as at a higher, more decision active level than data.

Quality and Age of Information:

Data varies in quality because of bias or errors. In most information systems, the receiver of data has little knowledge of either bias or errors that may affect its quality. If bias is known adjustment can be made for it. The problem is to detect the bias. The adjustment is generally fairly simple. Error is a more serious problem because there is no simple adjustment for it. The difficulties with error may be overcome by:

1. internal control to detect errors,
2. internal and external auditing,

3. addition of "confidence limits" to data analysis,

4. user instruction in measurement and processing.

The first two methods attempt to reduce the uncertainty about the data and therefore increase the potential information content. The last two provide the user with confidence limits; they can be thought of as adding to the information being provided by the information system by reducing the uncertainty about the nature of statistical errors.

Data can base its potential information content in time. Davis defines two types of data: (1) condition data which pertains to a point in time (a balance sheet for example) and (2) operating data which reflects changes in status during a period of time (inventories used during a month or sales for a week).

Both data, as collected and reported, can have a time interval. An information interval (i) is defined as the interval between reports: week, month, etc. The reporting delay (d) is defined as the processing delay between the end of the information interval and the issuance of the report for management use. Thus, maximum, average and minimum age of potential information in management reports is defined as follows:

	Condition Data	Operation Data
Maximum age	$d + i$	$d + 1\frac{1}{2}i$
Average age	$d + \frac{1}{2}i$	$d + i$
Minimum age	d	$d + \frac{1}{2}i$

where i = information interval between reports; d = processing delay. The most important concept for many kinds of information system design relative to the age of information is the impact of both the information interval and the processing delay.[1/]

Application of Information Concepts to Information System Design

The insights provided by the theory are several:

1. Information has surprise value.
2. Information reduces uncertainty.
3. There is no information unless there is choice.
4. Not all data that is communicated has information value.
5. Redundancy is useful for error control in communication.

The basic model of a communication or message transmission system in information theory is more complicated when humans provide links in the system. Humans are goal-directed, self-adaptive systems, which makes them more difficult to describe than a completely automated hardware-software communication system.

Information is associated with uncertainty because there is a choice to be made and the correct choice is uncertain. If there is no uncertainty, there would not be a need for information to influence the choice. Information received will modify the choice by altering the subjective estimate of the probability of success.

The need for a well organized, structured information system results not only from the time restriction and the difficulties involved in any management task, but also from the fact that human capabilities as information processors are limited. This is well illustrated by George A.

Miller in his "the magical number seven plus or minus two."*

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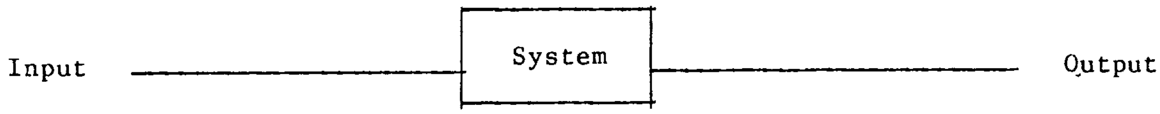
* In the Psychological Review, George A. Miller writes: "The span of absolute judgement and the span of immediate memory impose severe limitations on the amount of information that we are able to receive, process, and remember. By organizing the stimulus input simultaneously into several dimensions and successively into a sequence of chunks, we manage to break (or at least stretch) this informational bottleneck...And finally, what about the magical number seven? What about the seven wonders of the world, the seven seas, the seven deadly sins, the seven daughters of Atlas in the Pleides, the seven ages of man, the seven levels of Hell, the seven primary colors, the seven notes of the musical scale, and the seven point rating scale,... and the seven digits in the span of immediate memory? For the present, I propose to withhold judgement. Perhaps there is something deep and profound behind all these sevens, something just calling out for us to discover it. But I suspect that it is only a pernicious, Pythagorean coincidence." 8/

II. SYSTEM CONCEPTS

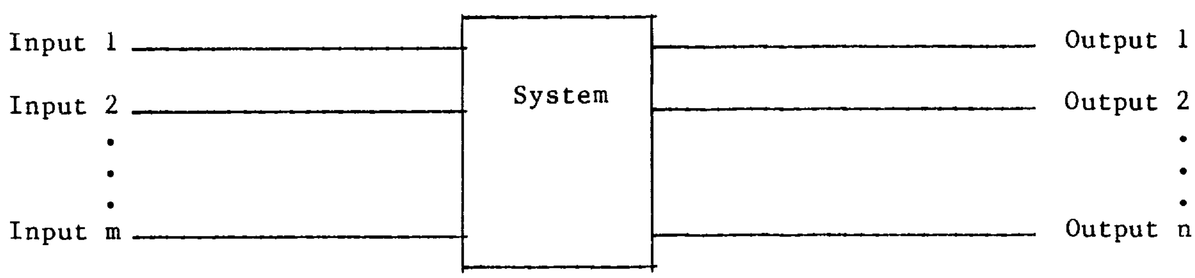
Definition, Characteristics, General Model:

A system can be abstract or physical. In either case it is composed of interacting parts that operate together to achieve some objective or purpose. 1/

A general model of a system is: inputs, processor, and outputs. The features which define and delineate a system form its boundary. The system is inside the boundary, the system environment is outside the boundary.



Simple input-output



many inputs - many outputs 1/

In some cases it is easy to distinguish between the elements of a system and the environment; in other cases, the person may arbitrarily define the boundaries. Each system is composed of subsystems which in turn are made up of other subsystems, each subsystem being delineated by its boundaries.

General Systems Theory:

In order to study the world we live in, men have developed scientific approaches and organized total scientific study into subfields or disciplines, founded on the following basic structure: [5/]

1. Abstract formal science (Mathematics, logic).
2. Empirical science:
   - 2.1 Natural science
     - physical science (geography, physics, chemistry)
     - life science (biology, botany)
   - 2.2 Behavioral science (sociology)
   - 2.3 Applied science (economics/business, engineering, medicine).

The aim of systems theory may be considered to be:

1. To identify structural functional amorphisms among systems.
2. To identify types of systems that appear to recur in various disciplines.
3. To identify types of systems that appear at various sublevels of a discipline.
4. To study how systems are structured and do behave - discriptive- and how systems should be structured and should behave (normative analysis).

Darwin's origin of species in which he integrated all life into a system of nature and indicated how the myriad of living subsystems are interrelated, and Keyne's general theory of employment, interest, and money where he connected many complicated natural and man-made forces which make up an entire economy, are well known works that represent an attempt to integrate a large area of inquiry.

One of the most important indications of the need for a general system theory is the problem of communication between the various disciplines: "Hence physicists only talk to physicists, economists to economists - worse still, nuclear physicists talk only to nuclear physicists and econometricians to econometricians. One wonders sometimes if science will not grind to a stop in an assemblage of walled-in hermits, each mumbling to himself words in a private language that only he can understand" [11/]

Boulding [11/] has proposed two possible alternative approaches: the first is the development of models common to many disciplines and the second approach is a hierarchical classification by degree of complexity which is indicated by definition of levels. (For those interested these levels are discussed in reference (2) by Murdick p. 412.)

Systems Classification:

Standford L. Optner, in his "Systems analysis for business and industrial problem solving" gives the following classification of systems which are said to be the most important ones: [5/]

1. Conceptual and empirical:

   A conceptual system deals with models or theories such as MIS or Decision Support Systems. An empirical system refers to a specific system in action, is operational and made up of people, materials, machines, energy and physical things.

2. Man-made systems:

   Born with the first gathering of men for living and hunting together. Today they range from manufacturing systems of a company to the system of space exploration.

3. Social and man-machine systems:

   The use of a computer creates a type of man-machine system for example.

4. Open and closed systems:

   An open system is the one that interacts with or adjusts according to its environment as opposed to a closed one which does not.

5. Permanent and temporary systems:

   Permanent systems last for long periods of time while a temporary one is designed to last a specified period of time and then dissolve.

6. Stationary and nonstationary:

   The stationary systems are the ones whose properties and operations do not vary significantly or vary only in repetitive cycles like automated factories, supermarket store operations etc.

7. Subsystems and supersystems:

   Smaller systems within a system are subsystems where a larger system is part of the environment. Supersystems denote extremely large and complex systems.

8. Adaptative and non-adaptative systems:

   Adaptive systems react with their environment so as to improve its functioning, achievement, or probability of survival. Animals, men and other living organisms, also successful business are an example of such systems.

III. CONTROL SYSTEM CONCEPTS:

"The objective of the system is to perform a specified function while the objective of control is to maintain a level of output which will satisfy the system requirements modified from." 4/ Thus, the objective of control is to determine the relevant characheristics which, when controlled, maintain the function of the system within allowable variations. This is not an easy task. Richard G. Canning, in his "Controlling a business process" mentions that "Too often, there is no one within a business that can clearly define the operation to be controlled, and usually the present data-handling system is rambling and redundant. The system engineer must define for himself what the control system must be able to do."

A system design and its operation are different things. It is easy to design a system with control elements but to make it operate within the objectives of the design is another matter. In designing a system the ultimate would be to have elements of control which compensate for environmental changes and still maintain the system in operation regardless of the degree of variation in input or the environment.

Control Defined, Elements of a Control System:

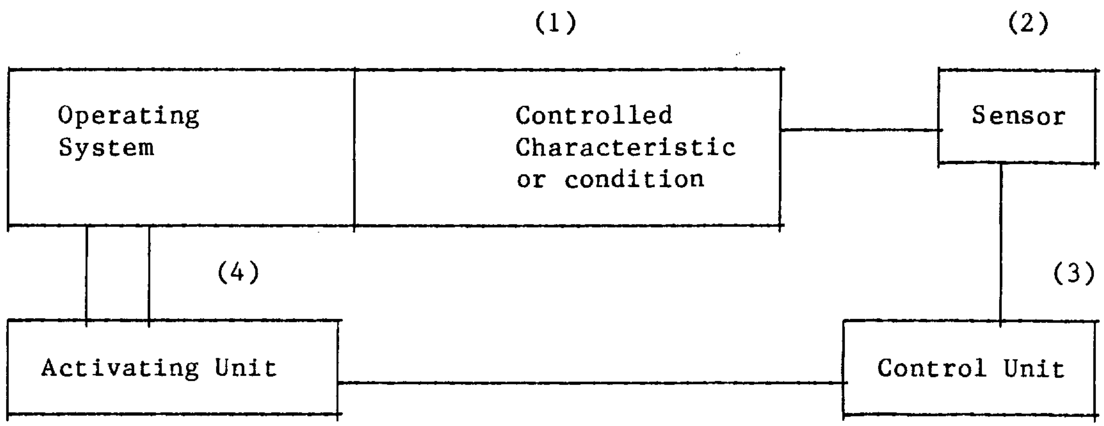
"Control is that function of an operating system which provides direction in conformance to the plan, or in other words, the maintenance of variation from system objectives within all allowable limits." 4/

There are four elements in every control subsystem; they may be observed in a common sequence and relationship to each other:

1. A controlled characteristic or condition,
2. A sensory device or method for measuring the characteristic or condition,
3. A control unit which will compare measured data with planned performance and direct a correcting mechanism in response to need.

4. An activating unit or mechanism which is capable of bringing about A change in the operating system.

The figure below illustrates the relationship among these four components:[4/]



The first element may be the rate of output during any stage of processing or a condition resulting from the output rate of the system.

The second element is a sensory device for measuring the rate or condition.

The third element receives the measure, evaluates it, determines if there is a need for correction and releases corrective instructions for action based upon previously specified decision rules.

The fourth element of a control system, implements corrective action, through a device or method which adjusts the inputs of the operating system. The controlled function is, therefore, categorized by the controlled characteristic, sensor, control unit and activating unit - all interlinked by a flow of data.

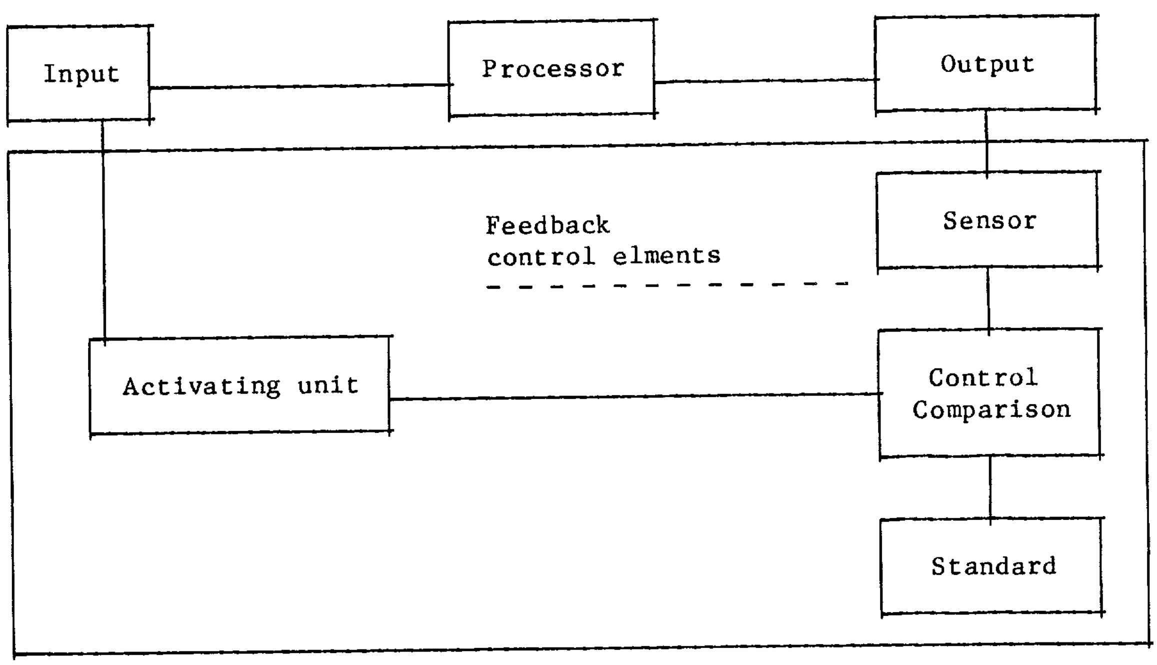
Kinds and Types of a Control System:

G.B. Davis [3/] defines two kinds of control loops:

• A closed control loop is a completely automated control system or subsystem such as a thermostat or computer controlled precess which contains adequate decision rules such that no human inference is required in operation.

• An open control loop is one with random distrubances (elements) for which complete decision rules are not pre-programmed and a human element is required to deal with exceptional cases.

A continuum exists between open systems with human controls and closed systems with complete machine controls. A man/machine system is therefore an attempt to use the best characteristics of both to make the system as closed as possible. The figure below shows a feedback loop in a system.



Feedback loop in a system 1/

Ideally, there should be at least as many variations of control adjustment as there are ways for the system to get out of control. The manager can handle this by subdividing the system and assigning a subsystem to control the subdivisions.

Almost every type of control falls within one of these categories: [11]

1. Preliminary controls: (before). It is used to prevent deviations by making sure that all anticipated misfunctions has been taken care of including human, financial, and material resources and systems preparation.

2. Concurrent controls: (During the time period of system operations). These controls monitor operation in progress, i.e., maintain qualities and quantities of inputs and outputs at standard levels.

3. Feedback controls: (After). The purpose of a feedback control is to improve the next cycle or project. It derives its name from the fact that historical results guide future action. This method includes analysis of budgets, standard costs, financial statements, quality control, and pilot programs. Learning and through it improvement in a system performance can occur through feedback which capture data through time and consequently improve system predictability as well as the ability to answer "what if" questions concerning the production process.

IV. MANAGEMENT INFORMATION SYSTEM (MIS)

MIS defined:

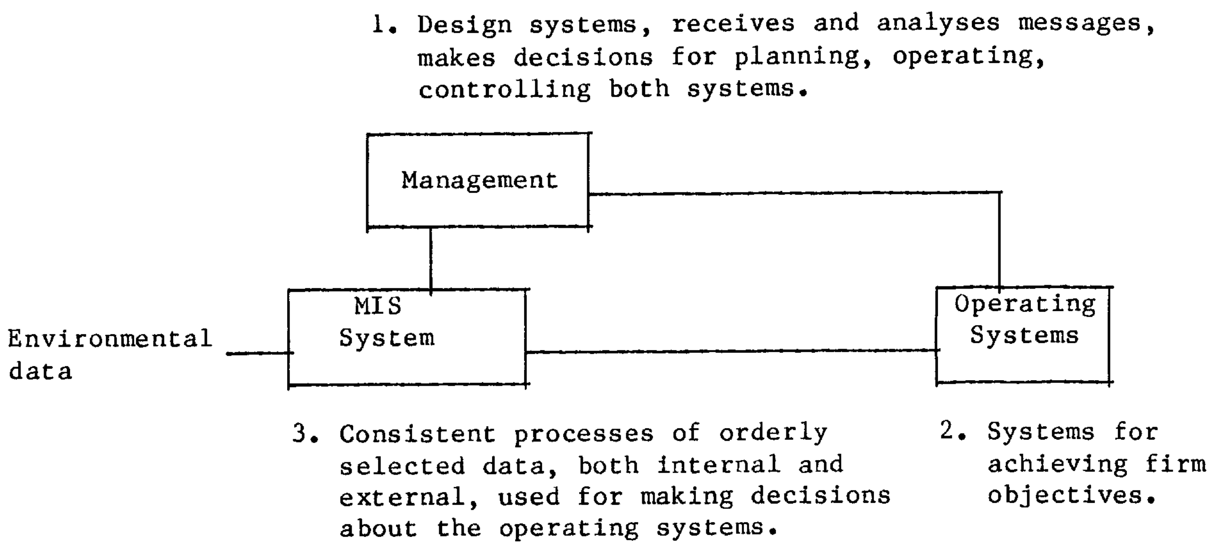
The term MIS is commonly used in business literature to refer to any computerized data systems. This is not necessarily a proper use of the term. John Dearden [9/] paraphrased MIS as follows: "A MIS is an organized method of providing past, present and projection data of high (informal) potential relating to internal operations and external intelligence. It supports the planning, control and operational function of an organization by furnishing (standardized and exceptional data) in the proper time-frame to assist the decision making process."

In response to J. Dearden, James C. Emery and Cristopher R. Sprangne[10/] propose the following characteristics for a well designed MIS:

1. It can be based on the use of one or more computers.
2. It offers a variety of decision aids.
3. A MIS thus cannot be categorized as either exclusively computer-based or all encompassing. Its boundaries shifts with changes in needs and advances in technology.
4. A system is composed of a collection of subsystems which may have varying degrees of integration among the parts at any given stage of development.
5. Implementation of a MIS involves both centralized and decentralized development of subsystems.
6. Implementation of a system proceeds over many years, and in fact continues indefinitely. It is a dynamic entity.

Murdick [2/] defines MIS as follows: "MIS is the system which monitors and retrieves data from the environment, which captures data from transactions (transfers) and operations within the firm, and which filters, organizes, and selects data and presents them as potential information to managers."

A diagram of the use of a MIS as seen by Murdick is as follows:



A (computerized) MIS includes three elements: [1/]

- physical components which may include hardware (computer, data preparation equipment, and input/output terminals), software, files (data base), procedures such as user instructions, instructions for preparation of input, or operating instructions for both MIS personnel and operating personnel.

- MIS processing functions consists of:
  - data processing functions
  - maintaining historical files
  - reports production and other output
  - interaction with users.

- MIS output for users may be classified in five major types:
  - transaction documents
  - preplanned reports
  - preplanned inquiry responses
  - ad hoc reports and inquiry responses
  - man/machine system dialogue.

The above outline describes a formalized MIS. At another less structural level all managers can be said to use an informal MIS as they conduct their affairs. At issue to a manager is the proper level of formalization in terms of benefits and costs with due recognition of the knowledge base, the potential for learning, the reoccurring nature and the frequency of the decisions which are routinely and occasionally required.

Structure of a MIS:

The structures of concern here are the ones dealing with the major activities of management control and planning. They are: 2/

1. Operational control:

Which concerns the way operations are carried out, the effectiveness and efficiency involved. The processing support for this activity are:

- transaction or event processing: data collection and storage
- periodic status report processing and,
- special inquiry processing due to questions raised or problems perceived.

An operations management control system is designed to help managers in measuring performance, decide on control actions, and implementation of adjustment decisions. Four types of data are needed:

- planned performance: standards, expected, budgeted, etc.; the "normal"
- variances from planned performance; the deviations
- reasons for observed deviations
- analysis of alternative courses of action.

Two types of data bases are involved: one is provided by events data on operations. THe other is the related plans, standards, budgets, etc. To support management control, the following are the processing requirements:

a) planning/budget models

b) deviation reporting modules

c) problem analysis modules to assist adjustment through decision making

d) Inquiry modules to assist in responding to inquiries concerning operaton status.

2. <u>Strategic Planning</u>:

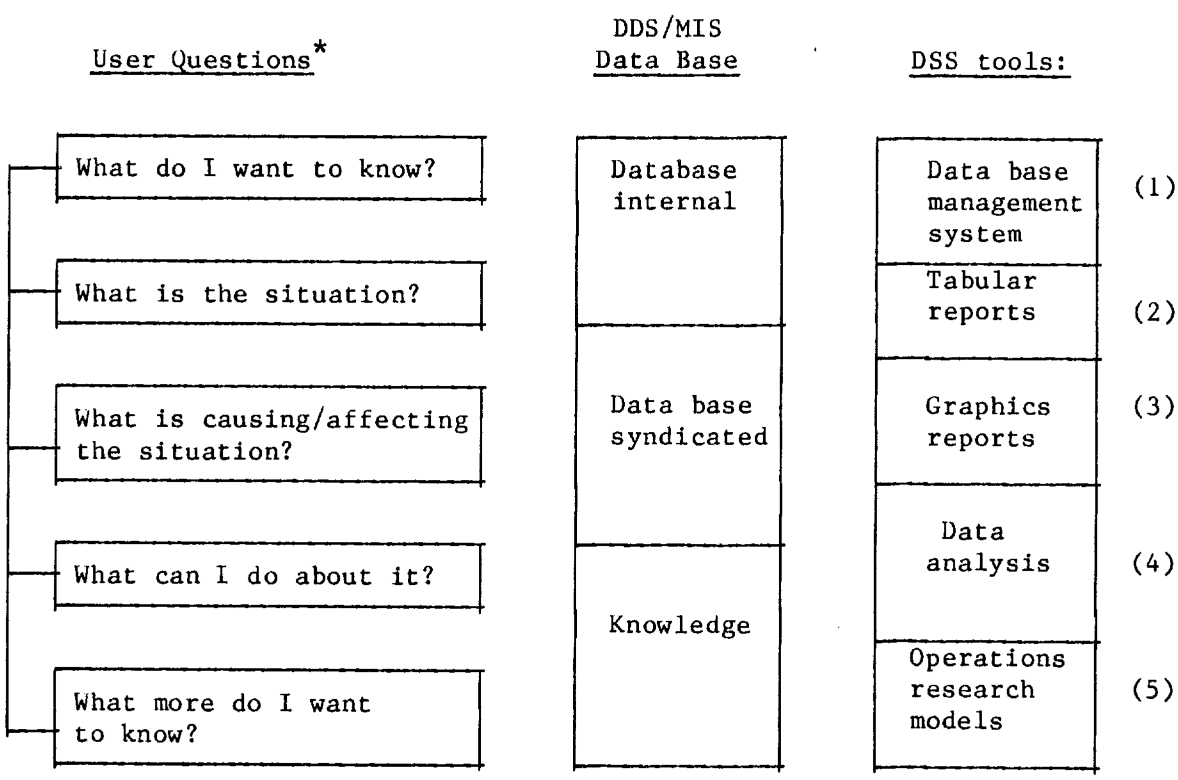
Which consists of the strategy that is used to achieve broad objectives. The time span involved tends to be longer than for control and shifts in the organization are likely to happen. Data are generally required from a variety of sources in and outside the firm. Strategic planning activities may be somewhat irregular and much of the data cannot be easily collected on a regular pre-programmed basis as it can be in operations control.

V. DECISION-SUPPORT SYSTEMS (DSS):

The emphasis on decision-support systems (DDS), as classification to the concept of a MIS, is becoming increasingly wide spread. DSS is said to allow managers to retrieve essential data from centralized data bases, to create decision aiding models and to refine status reports.

According to visiting professor Kenan Sahin of the M.I.T. Sloan School, "By definition, DSS is interactive, and that means doing away with the old system where the user (manager) tells the expert what he wants and the expert obtains it."

The figure below illustrates how a DSS works:



*Business Computer Systems, July 1984, p. 47.

The data base management system locates, sorts, updates, and integrates data from different sources, data bases and types of files (accounting, marketing, general ledger for example). A report generator linked to the DBMS can assist in presenting or arranging the data in a way that helps the user better understand its significance. It may rank, summarize, consolidate it, break it out by location, group, lot, etc.

Graphics applications can present data in a way that may give it new significance.

Operation analysis can develop rules, relations and formulas to describe how different elements and factors interact with and affect one another.

Models incorporate the rules and formulas generated by analysis, along with technical and economic rules, factors and constants (such as interest or inflation rates, or a firm's marketing policy) to stimulate a past, current or future situation.

<u>DSS is powerful</u>:

DSS models often incorporate far more complex formulas and equations than does the average micro spreadsheet type analysis.

The power of the DSS approach lies in its adaptability to various management approaches and styles. It allows for the use of both hurestic approaches and operations research tools. Microcomputer packages like LOTUS 1,2,3 resemble the DSS approach, but the current generation lack the powerful analytical and processing tools exist on some standard mainframe DSS equipment.

Most micro spreadsheets have a two dimensional structure, but a mainframe DSS program can analysis up to nine dimensions. In time newer micro software and more powerful micros will lessen the difference. However larger firms will still require net worked computing systems plus large data base maintenance at central locations.

Probably the most important strength of the DSS approach is structural analysis. It has the ability to develop formulas to describe the complex relationships between business elements and economic factors.

However versatility is one reason large DSS packages are hard to learn even by well trained users. The documentation is time consuming. The Express User Manual, a mainframe system, fills two books approximately the size of Webster's Unabridged Dictionary. But once the user becomes comfortable with a state of the art DSS in its command form, he can use it to create menu-driven applications for routine use by more computerphobic and occasional user type managers.

Summary:

The concepts and ideas of the system approach were outlined here. The building blocks for development of MIS were noted as: information and data systems definitions, classification and concepts, control systems concepts, system structure and design and computers as a tool to organize such systems.

Once the concept of a system has been clarified one can develop a systems approach to the design of systems and to the analysis of problems. With time a system can be refined, employing subsystem complexity to try to optimize total system performance.

The potential of such tools to benefit business and society depends directly on the man's ability to manage the design of information systems.

Barriers and Benefits of the DSS:

*Barriers:	Benefits:
• Full commitment from top management.	• More in-depth analysis: increased alternatives to examine.
• Restructuring the current corporate data base and/or setting up a separate DSS system.	• Faster collection and anslysis of data.
• Needs a base of known macro-economic, industrial and internal models.	• Improved communication between management levels.
• Knowledge about model usage.	• More data integrity.
• Adequate security system.	• Cost savings through more economical use of syndicated and internal information systems.
• Protecting data and model bases from unauthorized modification.	• Better information on which to base decisions.
• Continuing end-user support.	• Effective teamwork.
• User training.	

* Business Computer Systems (July 1984 p. 54)

An increasing professionalism in systems design will enhance the ability of organizations to control data processing costs and performance and to more rapidly acquire the possible benefits of automation.

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