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Basic Concepts for Planning Advanced Electronic Data Processing Systems

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To take full advantage of new computer capabilities, management must define its computer objectives more clearly than ever before. Two major systems plans are taking shape as the—

BASIC CONCEPTS FOR PLANNING ADVANCED ELECTRONIC DATA PROCESSING SYSTEMS

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DEVELOPMENTS in digital transmission, the availability of faster bulk storage devices, and the use of man/machine interface devices such as display equipment and interrogation consoles have stimulated a new kind of data processing. In this processing, information is entered into the system as it is generated and outputs are requested as they are required. These inputs and outputs are occasioned by external stimuli – man or machine – to which the computer responds.

To take full advantage of these technological advances, management must abandon the hit-or-miss approach that has hitherto characterized much of its use of computers and develop a basic data processing philosophy. A reliable management information feedback system cannot be achieved without well defined data processing objectives and concepts.

Data processing specialists are proposing two divergent concepts, either of which could be used as a foundation for planning electronic data processing systems. They are the *total systems concept* and the *single information flow concept*. The purpose of this article is to define and evaluate these two concepts to help computer users decide between them.

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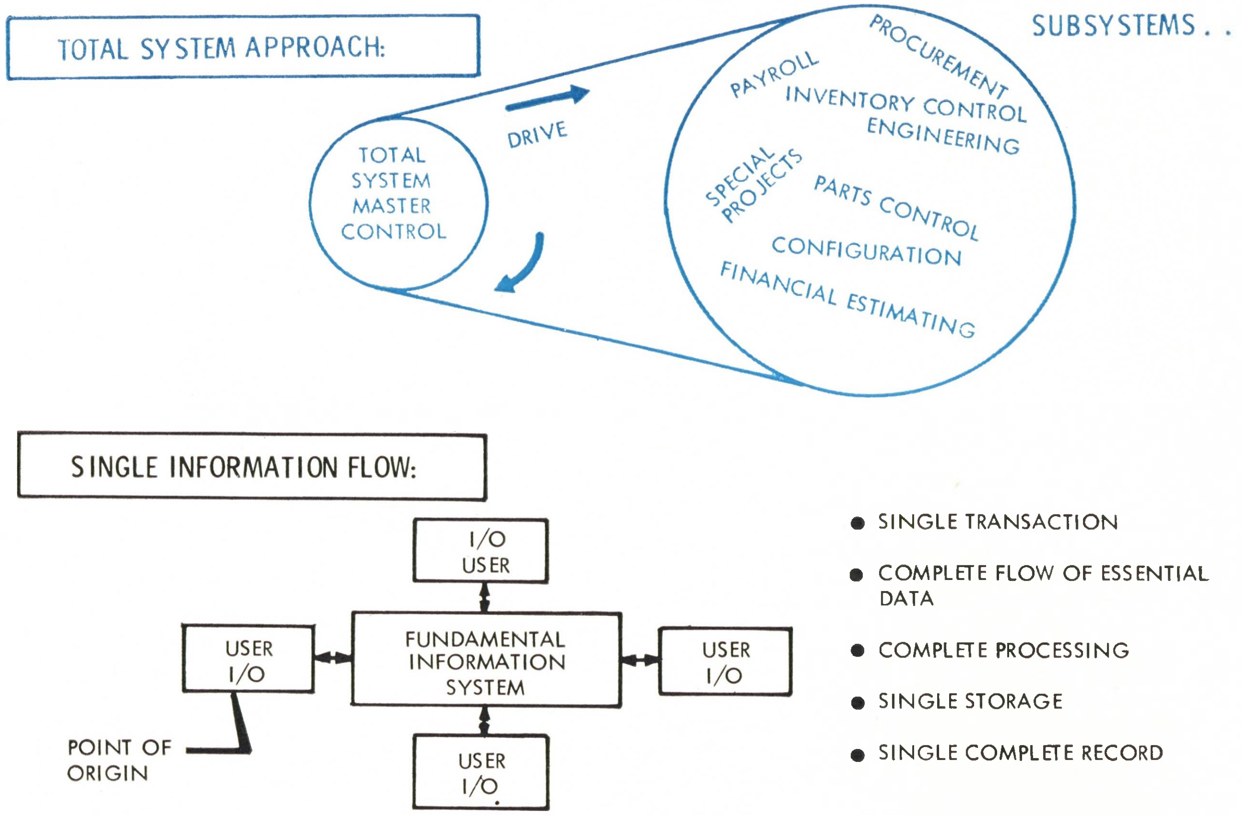
Definitions

The total systems approach is the logical final goal of many companies' existing computer installations. It has evolved from such techniques as "batch systems" and "integrated systems."

In this approach, major functions such as inventory control, purchasing, payroll, and the like are considered separate subsystems. These subsystems are treated on an inte-



DEFINITIONS

EXHIBIT I

grated (or compatible) basis; for example, the payroll subsystem is set up so as to run with the labor distribution subsystem, or the inventory control subsystem with the purchase order subsystem. Ideally, through evolutionary reprograming and redesigning where required, there evolves a single executive control subsystem that monitors subsystem integration, produces desired reports, controls run sequence and operations, and, to some degree, automatically changes programs as required.

The single information flow philosophy,[1] I believe, is the philosophy of the future in data processing. In this approach, all "essential" information is recognized to be completely interdependent. The goal is to enter a single piece of information into the data processing system only once in its history; from then on it is available to serve all requirements until its usefulness is exhausted.

This approach is sometimes called the "single transaction processing" or complete "single record" concept; sometimes it is known as the "total information system." Regardless of the name, this concept can be made workable only by observing the following rules: All information introduced into the system must be essential to the conduct of the business, and it must be part of a single flow of information.

Much information being processed in present-day computer operations is not "essential" in the sense in which this term is understood in single information flow theory. Nonessential types of information include "protective" reports such as auditable facsimile cards and special audit runs; multitudinous repetitions and overlapping of the same basic data records maintained by different departments; and special reports for which the need has long since disappeared.

The single information flow concept might be likened to the efficient one-man storekeeper, who came quite close to ultimate real time random access information handling. The cans on the shelf and a few pencil marks gave him both inventory and purchasing information; the book next to the cash drawer provided accounts receivable, credit, and customer information; the bank book plus cash drawer gave him his cash balance; and accounts payable were visible on

[1] Alfred L. Baumann, Jr., "Single Information Flow Philosophy," *Data Processing Year Book,* American Data Processing, Inc., Detroit, Michigan, 1963.

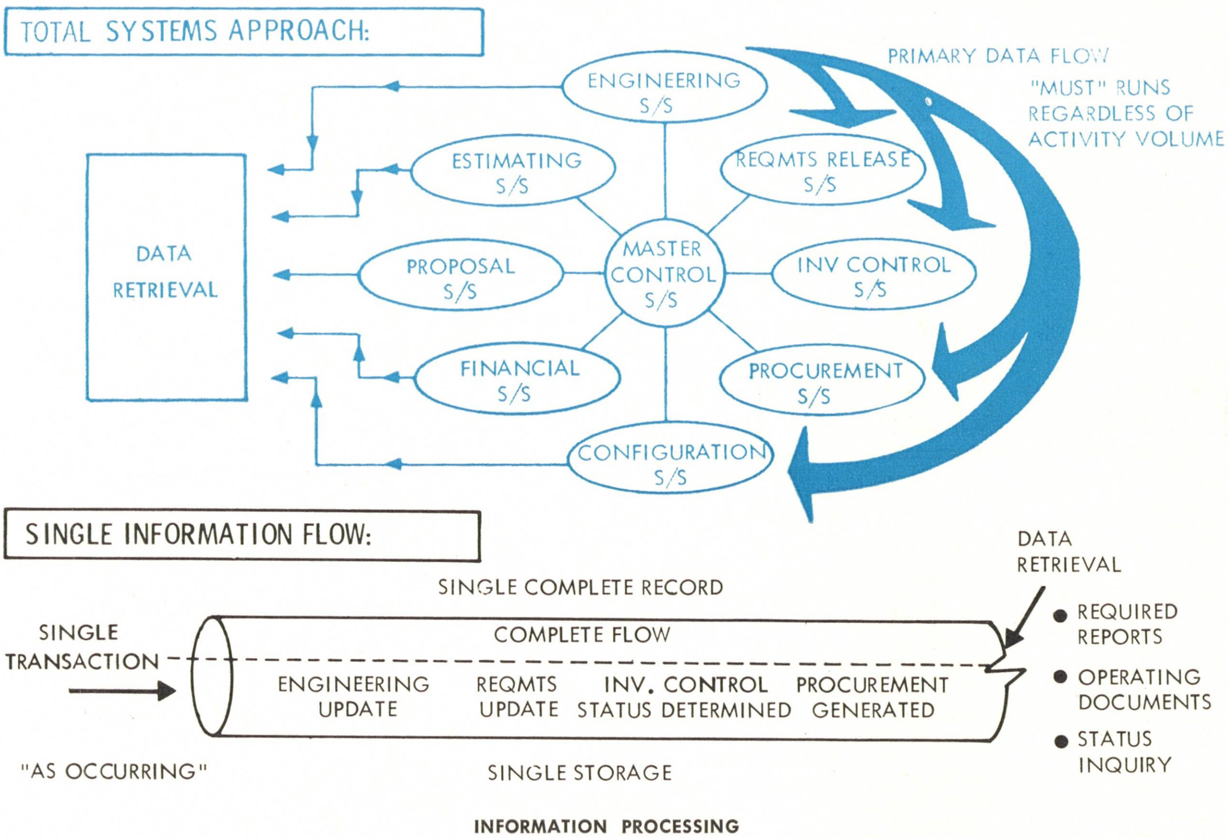


EXHIBIT 2

the nail on which he spindled the bills. In the drive for apparent efficiency, computerized organizations began to specialize and to batch operating information, thus delaying the feedback.

Ideally, under the single information flow philosophy, a piece of information is retained in only one place and is available for all necessary uses. For example, when the engineering department releases a part with its material requirements, inventory status and on-order conditions (including procurement) are immediately updated through a complete information flow and processing of transactions, with the result that all the proper actions (buy, issue, manufacture, etc.) take place as needed. All status reports, both in units and in dollars, are then taken from this single common source data. It is somewhat similar to taking a picture of a condition without double exposing or varying the time.

Basic environment

The two approaches differ in their basic environments. The total systems concept is output-oriented.[2] Files and data processing procedures are established to provide end products that meet specific user requirements. Information orientation is by particular functions or departments. Applications are specialized to meet particular needs.

Processing is predominantly of the batch type. Data are collected over a period of time for processing during a particular machine run. The same information is read and re-read into the computer following various sorts and merges with other data. Files are run sequentially regardless of the amount of activity. Because much of the data processing operation is conducted off line, there is high use of peripheral equipment. Control and audit of data also take place off line; manual calculations and various audit comparisons may be involved.

The future trend of the total systems approach may well be toward multi-computer operations. It may, indeed, foster a decentralized data

[2]Gregory and Van Horn, *Automatic Data Processing Systems — Principles and Procedures,* 2d ed., Wadsworth Publishing Company, Inc., Belmont, Calif., 1963.

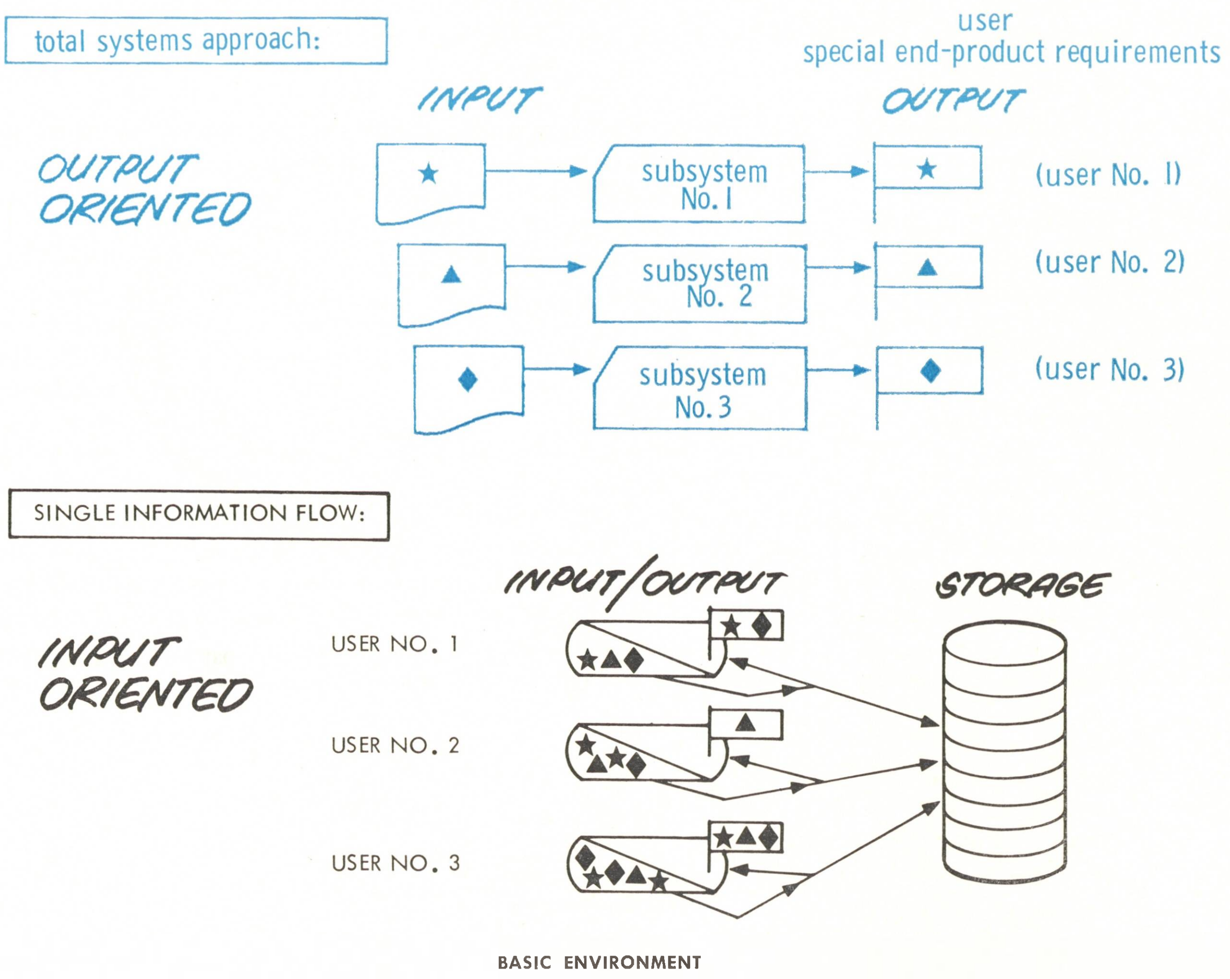


EXHIBIT 3

processing environment, in which the user processes his own data on less sophisticated peripheral computing equipment while complex data processing remains with the centralized main frame computer. As the number of computers and the number of users demanding to process their own data increase, there will be pressure from the users for current data under their own control.

The single information flow concept, on the other hand, is input-oriented.[3] The system is organized so that essential data are inserted into a common reservoir through point-of-origin input/output devices. User requirements are then satisfied from this reservoir of fundamental data about transactions.

Thus, the single information flow concept is characterized by random entry of data, direct access to data in the system, and complete real time processing.[4] (As soon as a transaction occurs, all the necessary and related records are updated and posted.) This method of single-transaction processing provides fast response, a high degree of reliability, and an easily expandable system.

Information orientation, instead of being toward individual users, fits overall company requirements. It is likely to cut across departmental and functional lines.

Planning objectives or operational targets are associated with "fundamental" record information. Exceptions are noted at the time of processing.

This approach will easily facilitate the use of "time sharing" by a number of users and the use of "implicit programing" techniques (direct decision making). (The term "time sharing" means that user groups can share time in common on the company's centralized business computer.) In addition to intradivisional user-group time sharing on the central computer, interdivisional time-sharing operations can be established on the same basis.

Implicit programing permits di-

[3]Ibid.

[4]Real time processing may be defined as the performance of a computation during the actual time that the related physical process is occurring so that results may be used in guiding the physical process.

Time-sharing operations will probably result in centralized computing facilities ....

rect man/machine decision making via input/output display devices. Explicit programs, in contrast, have to be written before man/machine decision making can take place.

Time-sharing operations will probably result in a trend toward centralized computing facilities and decentralized input/output equipment for insertion and retrieval of information. This will permit development of man/machine simulation techniques, which will enhance managers' systems understanding, broaden their training, and eventually facilitate direct decision making.

The two basic data processing concepts also involve widely differing equipment concepts. The choice between them will have a major impact on the choice of equipment throughout the data processing system.

Equipment concept

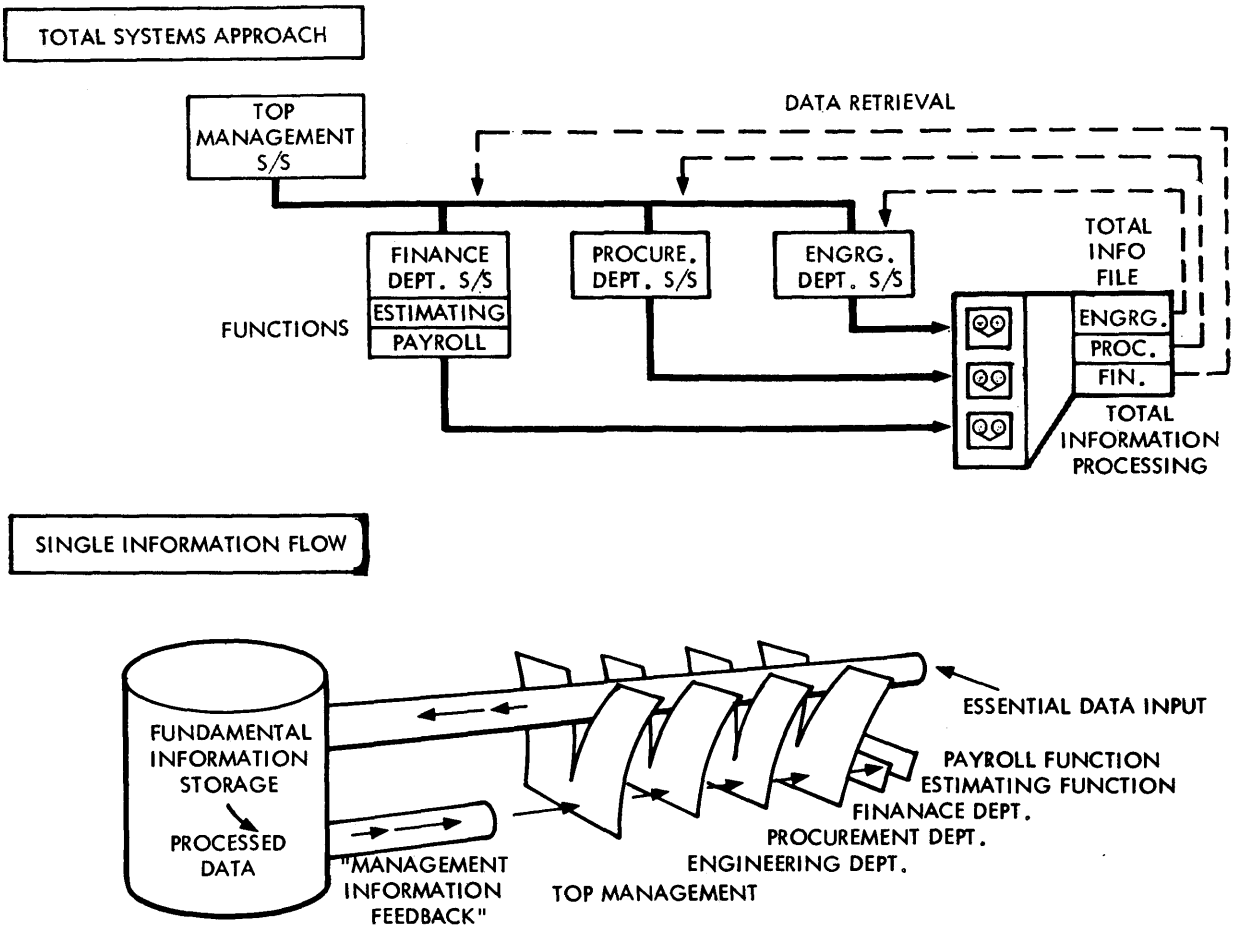
Adoption of the total systems concept imposes a need for high speed of operation to compensate for redundancy of data and for long subsystem computer runs. A large amount of high-speed storage will be required. Sophisticated peripheral equipment — almost with the capability of small computers — will be needed to reduce the load on the central main frame computers and solve the "input/output constraint" problem.

Each individual user's file will have to be stored separately — on disks or drum — and accessed by name only through a file directory. If time-sharing techniques are to be used under this concept, great care must be taken to protect the user programs from one another in order to preserve their integrity and independence. "Cross talk" between users will be tightly restricted.

Equipment for use under the single information flow concept, on the other hand, will need to possess

EXHIBIT 4

BASIC ENVIRONMENT
Information Orientation



on line-real time capabilities. Storage will also have to be of large capacity, but it need not be high-speed.

Much of the equipment emphasis will be on communication systems to connect users with the central processor. Instead of satellite computers, users will want point-of-origin input/output devices.[5]

With the use of communication equipment appropriate for time sharing, communication among users will be encouraged. Cross talk will be the rule rather than the exception.

Individual user files will not be maintained. Instead, there will be a single record file accessible to all users. Nonessential data and data not needed to update records will be processed directly through cross talk between user point-of-origin devices. Such data could be documented if need be through an off-line printer.

Appropriate software techniques will have to be designed for information insertion and retrieval. Implicit (man/machine response) programing will be developed.

Advantages

Each of these concepts, of course, has both advantages and disadvantages. The chief advantage of the total systems concept is that it offers a relatively simple transition from existing systems. Mechanization can be accomplished piecemeal. Subsystems can be developed independently as they are required or as systems workloads and resources permit. Interdependence among subsystems is limited almost entirely to the need for agreeing upon and coordinating standard interface formats.

Thus, the total systems concept permits step-by-step phased achievement of automation. As each subsystem is mechanized, valuable experience is gained that can be applied to the next one.

The total systems concept has the additional advantage of lending itself to "productionization," meaning that set times can be set aside for and assigned to each subsystem. Much processing of data can be accomplished off line or on peripheral equipment, thereby leaving the main frame computer free for other uses.

Single flow advantages

The single information flow concept, however, offers a number of control advantages. Engineering, manufacturing, accounting, purchasing, material, and other departments all use the same data rather than different iterations of the same data. Since data are transported only once, they need only a single edit. Thus, it becomes economical for employees to exercise greater care in entering information into the system.

Real time processing permits current comparisons with planned objectives and exception reporting of out-of-tolerance situations. The centralization of operation characteristics of the single information flow concept makes control easier — and also makes it easier to determine data processing costs. Systems and programing revisions can be handled more rapidly by substitution of a computer program at a central location than at multiple locations with the inherent transmission distortions.

The single information flow concept also has the advantage of facilitating adaptive systems design. A system designed to make internally generated adjustments from source input is likely to be more responsive to additional requirements placed on it and less likely to require a complete overhaul from time to time.

Disadvantages

The total information systems concept presents problems of equipment efficiency and timeliness of data. Data handling by separate groups, often handling like data, fosters redundant data processing. Duplicate data storage causes inefficiencies. As subsystems feed data to each other, long computer runs result. Data are only as current as the frequency and length of running cycles permit.

Not only is there duplication of data, but it is difficult to reconcile records since files are altered, updated, and organized at different times in different subsystems. Since the same kind of data is stored in several subsystems, management reports will reflect the status of the data in the subsystem from which it was taken. Because data and transactions are intertwined among various subsystems, costs of data handling and processing are difficult to track down.

The total systems approach may fail to allow adequately for systems and data interdependency and the ripple effect of data. For example, the inventory control subsystem needs to have the on-order status data from the purchase order subsystem. The purchase order status subsystem needs to have total requirements data from the inventory control subsystem, which in turn should have current total requirements from the requirement subsystem.

Since the subsystems are, for the most part, designed separately by different individuals, different methods and principles are applied. This problem is aggravated, of course, by different user requirements of the same data.

As the number of systems increases, efficient scheduling of com-

[5]Richard E. Sprague, *Electronic Business Systems,* The Ronald Press Company, New York, N.Y., 1962.

puter and supporting tabulating equipment becomes difficult. In some cases a second or a larger computer may be ordered in order to avoid redesigning the system.

The disadvantages of the single information flow concept, on the other hand, lie more in the demands it makes upon systems and data processing personnel than in its inherent deficiencies. Both systems designers and programers will require training to assimilate new concepts. Systems designers will need communications knowledge and experience in addition to EDP knowledge. Programers will need training in the technical applications of random and direct access operations.

Reorientation of operations will require complex advance planning. User needs, equipment requirements, and programing needs will have to be analyzed. A fundamental information system for the entire company will have to be designed before this concept can be installed. Each step of the conversion will have to be planned and scheduled.

Impact

If the total systems concept is adopted as the cornerstone of planning, the following action is necessary:

1. Although this concept represents the ultimate sophistication of present-day data processing methods rather than a totally new approach, there remains the problem of integrating the various subsystems into a total information system. This requires proper data definition so that the system will be responsive to the needs of various levels of management.

2. The shortcomings of present operations must be analyzed in the light of the total systems objective.

3. An estimate of the total anticipated scope of operations must be made in order to establish realistic boundaries for resource planning.

If, instead, the single information flow concept is selected as the basic information systems concept, each of the following steps will be necessary:

1. The conversion from the old to the new information system must be planned. A step-by-step time-phased action schedule should be prepared.

2. If the transition is to be smooth, reorientation and training programs must be given for management, user groups, system designers, and programers.

3. Both management and operating personnel will have to make extra efforts to make sure they understand the communication aspects of the new concept.

Systems engineering

As is probably obvious from the foregoing, I favor the single information flow concept. It seems to me that this is the best approach if a company really wants an information system that will enable management realistically to weigh the effects of all business parameters on current and future operations and thus to optimize decisions. With such a system not only can corporate activities be analyzed and synthesized for management's review and tactical appraisal today, but ultimately simulation techniques can be used as predictors of the effects of long-range planning. This will allow management to determine the tactical decisions that should be made now to accomplish the strategic planning so necessary for success tomorrow.

The scientific concept by which the fundamental information system is best designed and implemented is known as business systems engineering. Business systems engineering may be defined as a formal awareness of the interactions among the various parts of a business complex. Until recently much of management education and practice dealt only with functional components of business—accounting, production, marketing, finance, engineering, and the like—that were taught and practiced as if they were unrelated subjects. Now attitudes have changed, and there is growing awareness that interactions and interdependencies among components of the system are more important than the components themselves. This awareness is the keystone of fundamental information systems design and of the single information flow concept of data processing.

Limitations of present concept

The present concept of business systems engineering has evolved over a number of years. In the early years of computer technology the components (subsystem) approach prevailed. At that time an integrated business information system was thought to exist if a business transaction element was introduced into the system and perpetuated in the system with a minimum of manual intervention. The assumption was that mechanizing data and providing it to operating groups would, per se, result in benefit to the company.

An alternative approach envisioned good business systems design as the mechanization of data for specific random jobs as dictated by the needs of operating groups, with reliance on the assumed economies involved in mechanized data production. Both these alternatives, of course, represent piecemeal static systems because they inherently lack the flexibility of systems design necessary to coordinate the overall business process.

Change in approach needed

The need for a change in approach has become obvious. The interdependence approach owes some of its impetus to the growing emphasis on long-range planning. In the development of multi-dimensional master plans there has been a tendency to ignore traditional departmental lines in favor of broad company functions and processes, analyzed in terms of problems and informational content. Long-range planning has also evoked interest in constructing organization models

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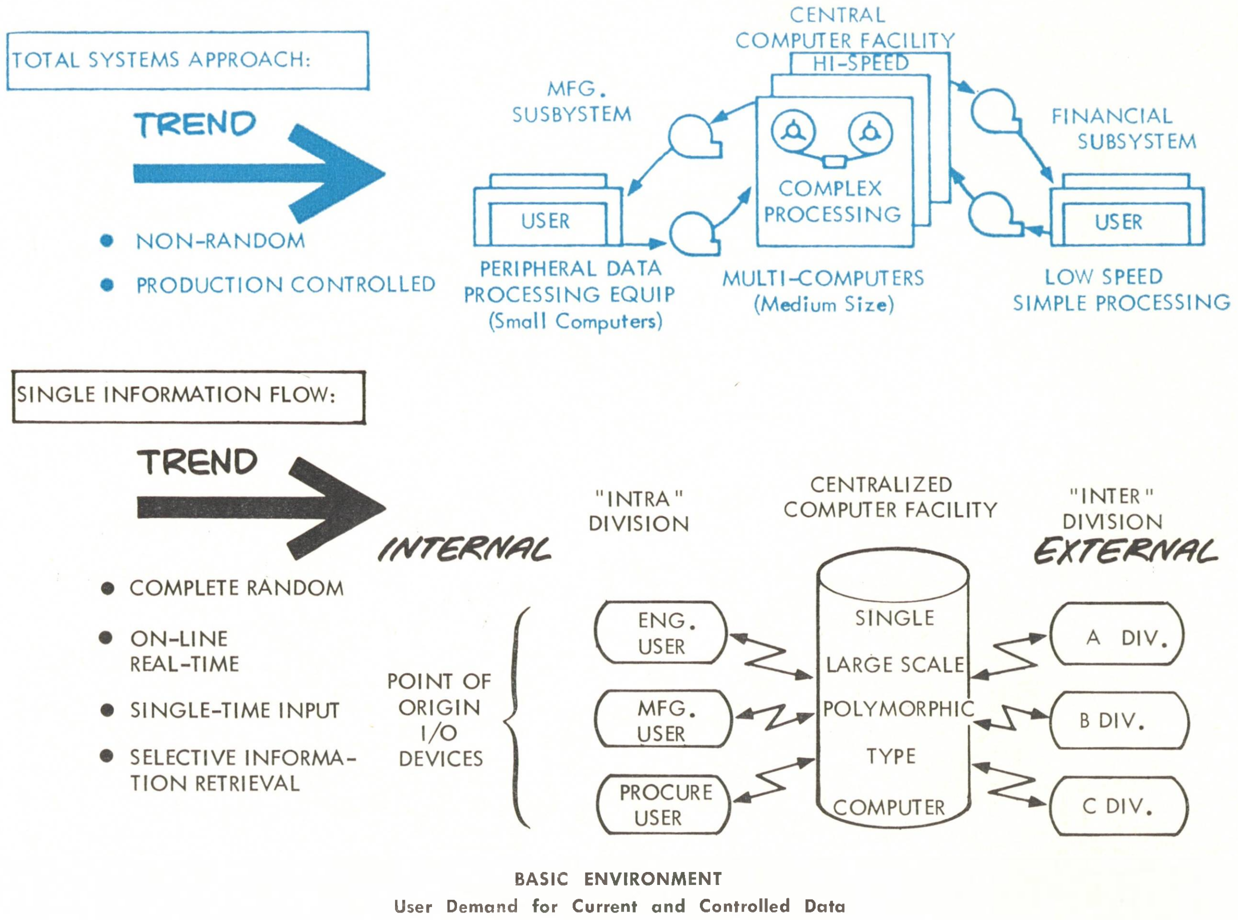


EXHIBIT 5

and examining them through simulation in an effort to predict the effects of proposed changes.

In terms of systems planning, the result has been a demand for analyzing company processes in a way that will permit mechanization of data elements at their source. The reason has been not only a desire to perpetuate the data in their original form but also the need for integrating the overall process and developing a truly realistic fundamental information system.

Systems design

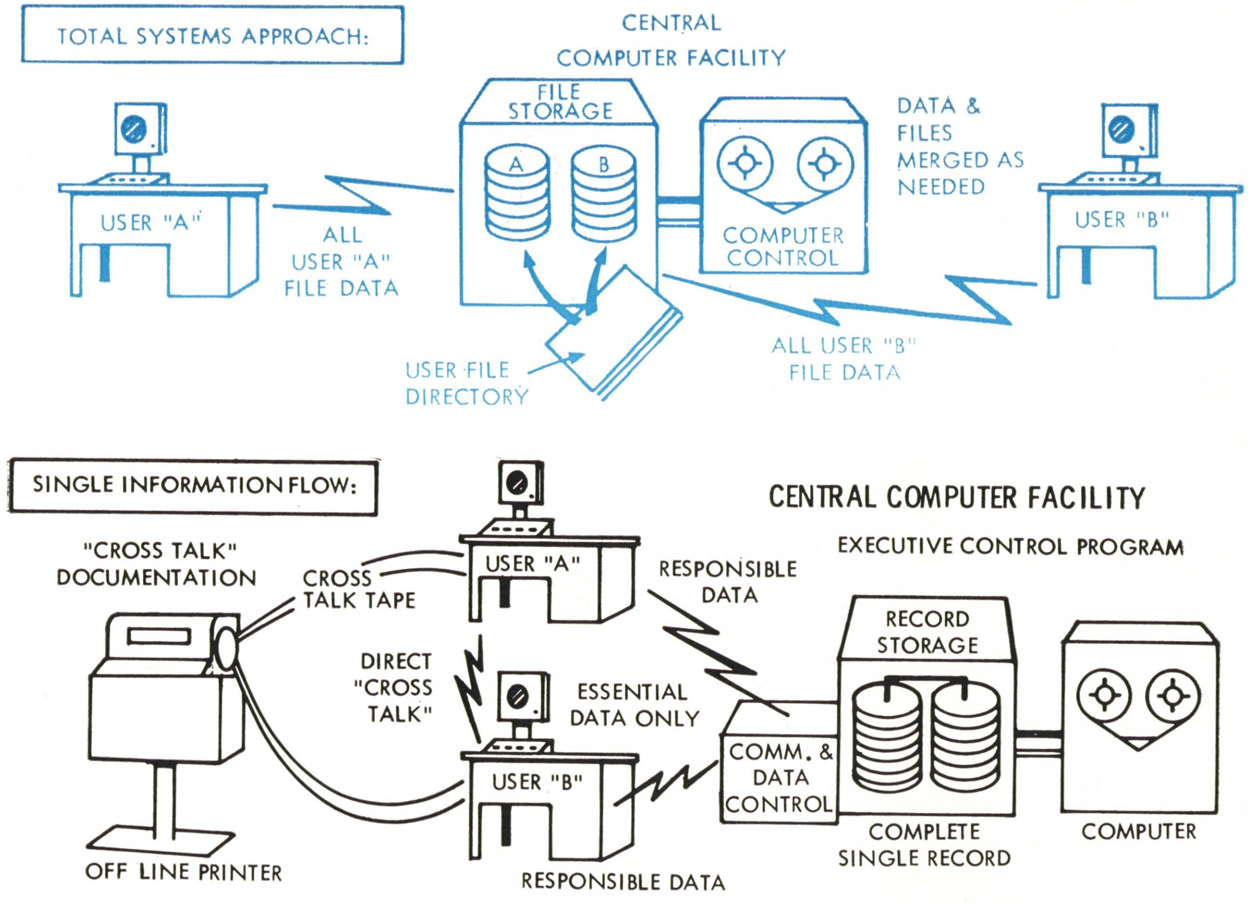
Whichever data processing systems philosophy is selected—whether the total systems approach or the single information flow concept—management must make the choice and then stick to it. Once the choice is made, then each of the following steps can be taken:

1. Management can begin to define its corporate objectives precisely.
2. All systems plans can become oriented to these objectives.
3. Each resource can be analyzed to determine its contribution to the objectives and its interdependency with other resources.
4. Standard information flow procedures can be adopted and software developed.
5. Management's information needs can be converted into specific output formats.
6. Input formats and controls can be designed.
7. Editing and processing subroutines can be written.
8. The files can be converted and the system installed.

Systems design must be oriented toward corporate management's responsibility for directing the various activities of the enterprise. Management's success depends upon its ability to establish well defined and measurable events within its area of responsibility. Competently designed information systems will reduce the efforts managers must exert in making routine decisions, enabling them to obtain short-run results with minimum difficulty, and thus allow them to devote their energies to the major decisions of business strategy and long-range planning. To achieve this goal, decisions must be harnessed under policy and controlled through integrated data processing systems.

A basic plan for designing the information system in a typical company might be outlined as follows:

1. Determine management's needs



EQUIPMENT CONCEPT
Time-Sharing Techniques

EXHIBIT 6

to monitor the enterprise as a whole.

2. Design the fundamental information flow, indicating the interrelationships of the major functions and data, such as engineering, manufacturing, marketing, and finance.

3. Develop in detail the "essential" information that each function requires to operate efficiently.

4. Determine each function's data and action requirements and their dependence upon other functions' actions and/or information.

After these steps have been completed, decision criteria responsive to management's needs can be formulated. In addition, measurable critical "information points" can be selected and a control network developed for economically retrieving and consolidating the information. Thus, management can be made aware of potential problems and their impact far enough in advance to take corrective action.

Implementation needs

After a satisfactory data processing approach and plan have been developed, they still have to be put into effect. The volume and ever-changing complexity of business data make it difficult to satisfy even the current needs of management, much less its need for longer-range planning. The problem is complicated by the need for interpreting the data and perpetuating the information involved in the decision making processes. Furthermore, the information has to be manipulated rapidly to make it meaningful now – for judgments to be made and decisions to be arrived at in time to arrest potential problems.

The answer to these problems, in my opinion, lies in (1) high speed data processing and communication equipment, (2) adoption of the single information flow data processing approach, and (3) a competent business systems engineering staff capable of translating these fundamental requirements into the necessary data collection, processing, control, and selective information retrieval programs necessary to maintain a current picture of business activity within the company for all levels of management.