INTRODUCTION

The achievement of a reliable management information feedback system is dependent upon meaningful and well-defined electronic data processing objectives and basic concepts. The purpose of this paper is to attempt to define those basic concepts which can be used as a foundation for planning advanced electronic data processing (EDP) systems.

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

For the future then a basic data processing philosophy is required to match these recent developments.

Two basic divergent data processing concepts for the future are being discussed in much of the electronic data processing literature today. The remainder of this paper presents each concept.

TOTAL SYSTEMS APPROACH VS SINGLE INFORMATION FLOW PHILOSOPHY

The total Systems Approach and the Single Information Flow Philosophy are the two fundamental concepts which analysts have been alluding to in many of their discussions, but to date have not defined these concepts in a manner which should and can facilitate the designing of an advanced electronic data processing system.

Figure 1 asks the first basic question, “Which is the driving gear?” That is, is the system to be designed based upon the total systems concept or the single information flow concept. And Fig. 1 also asks the question, are we user-oriented or fundamental information-oriented as we visualize our EDP systems?

Before we attempt to answer these questions, let’s first define the two concepts.

Definitions

The Total Systems Approach. This approach represents the final goal of computer installations of many companies today. It encompasses present data processing operations and thinking, and its most
A BASIC QUESTION: WHICH IS THE DRIVING GEAR?

Figure 1

TOTAL SYSTEMS CONCEPT

END
PRODUCT
INDIVIDUAL USER
REQUIREMENTS

FUNDAMENTAL
INFORMATION
FEEDBACK
SYSTEM

SINGLE INFORMATION FLOW CONCEPT

Figure 2 (the upper portion) reflects this kind of subsystems monitor.

Information processing requires that these subsystems be processed in an ordered sequence regardless of activity and that information be retrieved after each subsystem is run. This is indicated in Fig. 3 (upper portion).

Single Information Flow Philosophy. The new computer data processing of the future will be concerned with this philosophy.

In this approach it is recognized that all "essential" information is completely interdependent. The attempt in this concept is to enter only once in its history, a single piece of information to be processed, and from that time on it is available to serve all data processing requirements until its usefulness has been exhausted.

This approach has sometimes been called the "single transaction processing" or complete "single record" concept and in some literature it is known as "Total Information System." Regardless of name, the key to making this concept workable is under-

sophisticated ultimate development represents a future attainment of the complete "total systems concept."

The Total Systems approach has evolved from techniques such as "Batch Systems" and "Integrated Systems."

In this approach, major functions (operations), e.g., inventory control, procurement, payroll, reports, etc., are usually considered separate subsystems. This total systems approach recommends treating these subsystems on an integrated (compatible) basis—for example, providing the ability of the payroll subsystem to run with the labor distribution subsystem or perhaps the inventory control subsystem running with the purchase order subsystem.

Ideally, through evolutionary reprogramming and redesigning, where required, there evolves a single executive control subsystem which monitors subsystem integration, produces desired reports, controls run sequence and operations and, to some degree, will automatically change programs as required.
standing the following rules: (a) "Information must be essential to the conduct of business," and (b) "It must be part of a single flow of information essential to the operation of the business."

Statement (b) implies that much information being processed in present-day computer operations is not "essential." These nonessential types of information include "protective" type reports (e.g., auditable fax-cards, special audit runs), multitudinous repetitions and overlapping of the same basic data records (e.g., identical requirements data being held on the requirements file, then on the Inventory Status file, and also on the Purchase Order Status file, etc.), which are maintained on an unrelated basis to meet needs long lost through the evolution of time, and special requests the need of which has long ago disappeared.

This concept is likened to the efficient one-man storekeeper who came quite close to ultimate real-time random 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; while accounts payable were visible on the nail on which he spindled the bills. In the drive for seeming efficiency, computer organizations began to specialize and to batch-process information, which, of course, runs counter to this one-man type operation.

Figure 2 (lower portion) outlines the basic ingredients and the fundamental information system.

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, at the time Engineering releases a part with the needed material requirements, inventory status and "on order" conditions (including procurement) are immediately updated through a complete information flow and processing of transactions resulting in the proper action (e.g., buy, issue, manufacture, etc.) taking place as needed. All necessary status reports both units and dollars are then taken from this single and common source data. It
is like taking a picture of a condition without double exposure or varying time. The lower portion of Fig. 3 indicates the single transaction and complete processing technique.

Organizationally, the systems design technique varies according to the basic approach used. As Fig. 4 indicates, there is normally a specific systems engineer and programmer assigned to design and maintain each subsystem in the Total Systems Approach whereas the Single Information Flow concept provides for preparing the basic specifications of all categories of “essential” information before the system is designed. It is after this point that the specific systems engineer, programmer and communication specialist get together and start designing the system.

BASIC ENVIRONMENT

The two approaches differ in their basic environments. The total systems concept is output-oriented. 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. (See Fig. 5 upper portion.) 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 reread into the computer following various sorts and merges with other data. Files are run sequentially regardless of the amount of activity.

Information is oriented differently between the two approaches. In the upper section of Fig. 6 it can be seen that subsystems are but individual files of a total file and retrieval of information takes place on an individual file basis.

As the number of subsystems going “on-the-air” increases (Fig. 7), it will generate additional need for large computers and attendant peripheral equipments. Because much of the data processing operation is conducted off-line, there is high use of peri-
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 multicomputer operations. It may, indeed, foster a decentralized data 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. (See Fig. 8.) 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. 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. (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 programming" 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...
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 mainframe 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 director. 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. "Crosstalk" between users will be tightly restricted. (See Fig. 9.)

Equipment for use under the single information flow concept, on the other hand, will need to possess 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.3

With the use of communication equipment appropriate for time-sharing, communication among users will be encouraged. Crosstalk 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 crosstalk 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) programming 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 (see Fig. 10.)

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. (See Fig. 11.) Much processing of data can be accomplished off-line or on peripheral equipment, thereby leaving the main frame computer free for other uses.

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 make it easier to determine data processing costs. Systems and programming 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. (See Fig. 12.)

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,
BASIC ENVIRONMENT
USER DEMAND FOR CURRENT AND CONTROLLED DATA

TOTAL SYSTEMS APPROACH:
- NON-RANDOM
- PRODUCTION CONTROLLED

SINGLE INFORMATION FLOW:
- COMPLETE RANDOM
- ON-LINE REAL-TIME
- SINGLE-TIME INPUT
- SELECTIVE INFORMATION RETRIEVAL

The 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 computer and supporting tabulating equipment become 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 programmers will require training to assimilate new concepts. Systems designers will need communications knowledge and experience in addition to EDP knowledge. Programmers 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 programming 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 responsible to the needs of various levels of management. (See Fig. 13.)

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 programmers.

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. (See Fig. 14.) 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 piece-meal 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 multidimensional 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 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 system 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 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 "infor-
mation points" can be selected and a control net-
work 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 ac-
tion.

IMPLEMENTATION NEEDS

After a satisfactory data processing approach and
plan have been developed, they still have to be put
into effect. The volume and everchanging complexi-
ty 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 infor-
mation 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 com-
munication equipment, (2) adoption of the single
information flow data processing approach, and (3)
a competent business systems engineering staff (see
Fig. 15) capable of translating these fundamental
requirements into the necessary data collection,
processing, control, and selective information re-
trieval programs necessary to maintain a current
picture of business activity within the company for
all levels of management.
DESIGN OF THE INFORMATION SYSTEM

START WITH BASIC EDP PHILOSOPHY

"PRESENT EDP EVOLUTION"

TOTAL SYSTEMS CONCEPT

TOTAL INFORMATION SYSTEM DESIGN*

EFFICIENT DATA PROCESSING

"AN ENLIGHTENED APPROACH"

SINGLE INFORMATION FLOW CONCEPT

FUNDAMENTAL INFORMATION SYSTEM DESIGN**

EFFICIENT DATA PROCESSING

THE LONG WAY AROUND

BECAUSE OF TRADITION AND THE DESIRE TO USE WHAT ONE ALREADY HAS, DEVELOPMENT OF THIS INFORMATION SYSTEM WILL BE DIFFICULT. MANY OBSTACLES including complex data integration will have to be hurdled.

** SINCE THIS INVOLVES A COMPLETELY NEW DEVELOPMENT APPROACH, TIES WITH THE PREVIOUS EDP ENVIRONMENT ARE SEVERED MAKING THIS THE MOST DIRECT AND HENCE THE SHORTEST PATH.

REFERENCES


FUNDAMENTAL REQUIREMENTS FOR DEVELOPING A BASIC INFORMATION SYSTEM

HIGH SPEED EQUIP + SINGLE INFO FLOW APPROACH + BUSINESS SYSTEMS STAFF

PROPER EQUIP + D/P FOUNDATION CONCEPT + SKILLED PEOPLE

EQUALS...

CURRENT INFORMATION/DISPLAY FOR MANAGEMENT DECISION-MAKING AT ALL LEVELS

Figure 15