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Accounting & the computer: a selection of articles from the Journal of accountancy and Management services

American Institute of Certified Public Accountants (AICPA)

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The Journal of Accountancy
and *Management Services*

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Foreword

In the Spring of 1965, the Executive Committee and Council of the American Institute of CPAs approved a substantial program of research and education to deal with present and future effects of computers on accounting and public accounting practice.

As an adjunct to this program, it has seemed desirable to bring together in one volume a selection of related articles which have been published since 1962 in *The Journal of Accountancy* and the American Institute's new magazine, *Management Services.* These have been augmented by papers delivered at the Institute's 1965 annual meeting, and a glossary prepared by one of the national accounting firms.

The purpose of this volume is primarily to provide an introduction and orientation for accounting practitioners who recognize the potential impact of computers on their clients' accounting and their own practices. It assembles authoritative discussions of various phases of the computer revolution in accounting, with many case histories of events which have already occurred.

It is not, however, intended to serve as a textbook or detailed guide to practice: the subject is much too vast and complicated to be treated in depth in one comparatively small volume. Rather, the purpose is to present the accounting achievements and potential of computers in fairly broad perspective—to give the reader a general picture of what is happening and what is likely to happen in all phases of practice.

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Research, selection, arrangement and editing of the articles for this book were the work of Peter F. Kerr, assistant editor of *The Journal of Accountancy,* with advice and assistance from John J. Connelly, System Development Corporation, consultant for the Institute's computer project.

Contents

CHAPTER

1

Introduction

The Challenge of Automation

WILLIAM W. PARSONS

The Challenge of Automation

TODAY WE are living in the age of automation. The application of auto mated technology presents a challenge to our society that may have more profound implications than the harnessing of the atom. Computers are truly becoming a part of everyday life and creating an entirely new set of conditions for running business. One of the causes for this growth in computers is the remarkable increase in the generation and distribution of information.

According to one account, knowledge-producing occupations accounted for about one-tenth of the economically active population in 1900. In 1959, they accounted for about three-tenths. Assuming that productivity of people in these occupations has not decreased, it is evident that the rate of knowledge generation is sharply on the rise.

The information system

Some optimists see the computer taking all the drudgery out of human existence, freeing mankind to realize its full potential both creatively and spiritually. On the other hand, some pessimists see computerization as making more and more people jobless because of the increasing requirements for specialized skills which they do not have and can never acquire. The future probably lies somewhere in between. However, it is essential for people in management to recognize the inevitability (or perhaps "certainty" is a better word) of computers and automation in just about every aspect of our lives, and prepare to make the best of the situation.

One of the important things to understand about computers is that they are embedded in information systems. The computer is not an entity in itself but rather a part of something bigger—namely, an overall information processing system.

All accountants deal with "systems" and "procedures" in business. The dictionary definition of a system is: "An assemblage of objects united by some form of regular interaction or interdependence." A more practical definition is: "The study of organized processes for accomplishing certain objectives." But to simplify this word "system," the short-order restaurant will serve as an example of an information processing system. Information processing is essential to its successful operation and survival. A rotary drum (or spindle) with clips attached to it, located somewhere between the serving area and the kitchen, performs a number of interesting functions when viewed as an element in an information processing system.

In the short-order restaurant, "system" information about what is available, in the form of a menu, is transformed into oral instructions by the customer to a waitress who transcribes the information into written symbols on a piece of paper. The information is then transmitted to and stored on the spindle where, after a short (but sometimes *long*) interval, it is used to transform certain raw materials into "one hamburger with everything and hold-the-French-fries."

The spindle in this system functions as a memory for the cook. Information about what he is to prepare can remain stored in memory while he devotes his full attention to the preparation of hamburgers and scrambled eggs. Second, the spindle acts as a buffer. It accepts inputs at one rate (the waitress's) and delivers them at another rate (the cook's). Third, the spindle is a queueing device. It does all "standing in line" for the waitress and relieves her of the need to wait to put in an order. Fourth, it functions as a random access display device. The cook can twirl it around and see that he has three orders for chili dogs and two for eggs-up, and organize his work on the basis of the information displayed by the spindle. Finally, the spindle provides documentary evidence that can be consulted in case of an error. It does not blame anyone; it merely preserves what was on the order ticket for comparison with what is on the customer's plate.

It is sometimes useful to think of organizations as systems, and to think of people and equipment in organizations as elements of systems.

A more complex illustration of a system is the Air Defense System of the United States, a system that is now substantially automated.

Known as the Semi-Automatic Ground Environment system, (SAGE) the system consists of a number of direction centers, each responsible for defending a large area of the country against air attack. These centers are linked together so that they can communicate with each other, and also with higher headquarters. Each SAGE direction center is equipped with a large computer covering about 30,000 square feet of floor space and costing approximately $13 million. The direction center includes a great deal of additional equipment—display consoles, banks of switches for signaling the computer, radio and telephone communications, etc.

In SAGE, most of the processing of information about aircraft movements, their identity, the status of interceptors and ground-to-air missiles, and the direction of defensive weapons is carried out by the computer.

Since the computer and its associated equipment can handle only coded information, all of the data arriving at a direction center must be converted to "machine-readable" form. Information arrives from many sources: long-range radar, picket ships, airborne early-warning aircraft, interceptor bases, missile launching sites, adjacent direction centers, weather reporting stations, and the Federal Aviation Agency, which supplies flight plan information for identification purposes. All of this incoming information is sorted, stored, analyzed, and displayed on screens resembling television screens and shown to people responsible for air defense operations.

The functions of the SAGE computer and its equipment strikingly resemble those of the spindle in a short-order restaurant. First, in the same manner as the restaurant spindle, the computer serves as a memory device which stores information about weapons, weather, terrain, and so on, to be drawn upon as necessary by the operators. Like the spindle, the computer also serves as a buffer. It accepts incoming information and stores it temporarily until the remainder of the computer system is ready to use it. This delay may only be a thousandth of a second, but it enables the remainder of the computer to operate efficiently without appreciably slowing down the handling of urgent information.

The computer performs queueing. At any moment there may be several hundred incoming items of information that require processing, each with a different priority. These messages are automatically assigned to queues, according to their urgency, and the important ones are handled first, with the less important ones waiting a little while. The other system elements (the radars or the interceptor pilots) don't have to wait their turn to send in their data. The computer stands in line for them, just as the spindle stands in line for the waitress.

The display function is carried out by means of the consoles, panel lights, printers, typewriters, and card punches. These display devices provide human operators with information that they need for the decisions they must make and the judgment they have to exercise.

Finally, a record of what happened is maintained by the computer, usually in the form of magnetic tapes. If any questions arise about any event at any time, the computer record may be consulted just as the restaurant spindle may be consulted to check a customer's order.

The SAGE system is also a good illustration of the concept of real time systems for the management of information. First, the computer is used "on line"—that is, as an integral part of the total system, interacting continually with other system elements including radar, defensive weapons, and people. This is different from the general "off line" use of the computer for scientific or business data processing. However, "on line" mechanization has begun in such areas as communications switching, manufacturing process control, central information retrieval and library systems, and management control centers. Insurance companies were among the first to utilize electronic data processing and, while they previously did not seem to require rapid response to inquiries, a recent examination of their overall management and customer service considerations resulted in all of the major insurance companies placing orders for on line equipment.

The second important point is that the computer operates in "real time." All time is "real," of course, but to say that a computer is in "real time" means that its performance is paced by external events as they occur and must respond to them immediately. For instance, when radar echoes are first received from an aircraft, they must be processed without significant delay. This is different from periodic preparation of a payroll or updating of an inventory record—activities that have to be performed on time but not necessarily at once. In such situations the computer is said to operate in "non-real time." This is also referred to as "batch processing."

Another function that the computer performs in SAGE is that of control, which involves a data processing capability the restaurant spindle doesn't have. In the following example, the control function is performed both "on line" and in "real time."

The computer may be used to guide an unmanned interceptor or ground-to-air missile to destroy an aircraft determined to be "hostile." Once the launch order has been transmitted to the launching site and the missile is airborne, the computer begins to track it, using radar and beacon information. The target aircraft is also tracked, and an interception point is calculated. The computer determines the desired course of the missile and transmits instructions by radio to devices on board the missile that activate its control surfaces. When the missile follows these commands and changes course, the computer observes the effect and makes a prediction about the probability of interception. If necessary, it makes up a new set of guidance commands, sends them on, observes their effect, and repeats the process. If the target aircraft takes evasion action (and it had better), the computer calculates a new intercept point, and corrects its guidance commands. This process continues until the interception is completed and the hostile aircraft is destroyed.

While the computer is going through its control function, it is also making up displays that enable the human operators to observe what is going on and, if necessary, interrupt or override the computer. Assuming that all is going properly and no intervention is required by the operator, the whole process is completely automatic.

Control, of course, is as important in business as it is for the military. A military command and control system basically differs little from a business management information system. Where the Army's needs involve logistics, personnel and administration, intelligence, fire and control, the civilian equivalents include inventory control and traffic, personnel and administration, management reports, and production control.

Human judgment still on top

Although computers are no substitute for human thought and human judgment, there is scarcely any organization—large or small, public or private—that can't benefit from being considered (at least partly) as an information processing system. A computer doesn't have to be a part of every such system. One of the computer manufacturers has, for some time, offered to study the information requirements of a prospective customer, with a view to determining which of its computers might be best suited to his needs. This study is usually started after the potential customer has already made up his mind that he would like a computer. Frequently the study has revealed that by giving careful attention to the information requirements of people within the organization and by designing a reasonable system to satisfy them substantial improvement can be achieved without the computer. This outcome is sometimes disappointing both to the computer manufacturer and to the prospective customer, but it suggests that thinking about organizations as systems to process information helps avoid a very costly and completely unsatisfactory experience—automating present inefficiency. People in management need to understand that a computer is useful only if it is a part of an intelligently planned operation—a system. The term "system" is the key word.

A computer for everyone

Automatic equipment and the remarkable achievements of its designers and users are with us more and more each day. Not long ago, most people were separated from computerization by two obstacles: technology and cost. It was impossible for the average manager to use even the simplest machines. He needed people to write programs for the computer and people to analyze his problems and translate them into operations that the computer could perform. To some extent, he was insulated from the problems as well as the promise of automatic data processing because computerization was just too complicated, and costly. If the language barrier wasn't prohibitive, certainly the cost was. How many organizations could afford $13 million for a computer? The executives would look at the price tag and scream, "We can run a whole department on what it would cost to rent even a small computer, let alone one big enough to handle the complicated things we do!"

People in the systems business have been at work removing these obstacles. There are two developments that should convince an accountant that he is, or is about to be, face-to-face with computerization. The first is in the area of what are called "programing languages" and the second is in "time sharing."

Computer language is numerical (ones and zeroes, to be exact). But now there are techniques that make it possible for a computer to accept commands or inquiries in so-called "natural language"—the language of the user. There are also what are known as "problem-oriented" or "procedure-oriented" languages, closely resembling English, but containing some short-cuts and specialized symbols. There are computers that permit posing the question: "Where is the Grand Canyon?" And the computer program will print a reply that: "The Grand Canyon is in the State of Arizona." There are no codes, no intermediary—just the questioner and the machine, speaking the same language.

Of course, there's always cost. The computer large enough to handle the program that can locate Grand Canyon costs about $15 million, which is pretty steep. A large part of the answer to the problem of cost lies in the developments now taking place in time sharing.

Time sharing permits a number of people or organizations to use one computer simultaneously on completely different problems. This method of computer operation is possible because of the enormous difference in operating speed between computers and people. During the time it takes a human being to digest what the computer has just told him and then figure out what to ask next, the computer can handle a large number of completely different problems of other users and then return for the next instruction. No computer time is wasted waiting for the user. People find it very difficult to turn their attention from one thing to another quickly, and they find it almost impossible to do several things at the same time; but the computer doesn't care what it is doing. It is a kind of intellectual one-man band, and it can skip from payroll to translation to orbit calculation to election prediction to stack gas analysis and back to payroll—and never get things mixed up.

There are several large computers on which time can be bought for about $500 an hour. A hundred clerks could be hired for that much. But suppose the use of the computer involves an aggregate computer operating time of one second, and fifty-nine seconds for printing out results. Using the time-sharing system, the cost could possibly be around ten dollars. By settling for a console display instead of a print-out, the cost could conceivably be cut to less than twenty-five cents.

It is not inconceivable that the day will come when there will be an information utility—an interconnected network of computers, a vast collection of data about things and people and events, and perhaps millions of subscribers making use of the system in much the same way as we now use the telephone or other public utilities. Some of the elements of such a system already exist, although they are rather loosely organized. You call the reference librarian at the public library and have her look up something. You can dial a telephone number and find out what time it is. Another phone number gives you a weather report; another gives you information about still other numbers you may want to call. You turn on your radio or television and select, from the countless bits of information filling the ether, those that suit your purposes. You can also *turn off* your radio or television set. And it is possible for you to have an unlisted telephone number. A service is available to banks in New York City which processes savings and mortgage accounts by connecting subscribing banks' teller machines via telephone lines with a data processing center. Similar on line computer processing centers are now being planned for banks in many other large cities.

With the ultimate information utility, techniques would have to be developed to continue to protect the privacy of the individual citizen while, at the same time, making information concerning him available to agencies that have a legal right to it. We would have to take steps to prevent accidental or deliberate damage to stored data and intentional or unintentional errors in transmission processes.

These are technical problems that can and will be solved, but the biggest problem in connection with bringing an information utility into existence is the inevitable resistance to it. One aspect of this resistance was expressed by a distinguished jurist commenting on the implications of information processing for the practice of law. He pointed out that an attorney doesn't *want* all the facts about a case when he is preparing his case. Some facts he would probably rather not know, and some precedents he would rather not find. For him, some information has negative value; for opposing counsel, the sign is reversed.

Simulation and the computer

There are some computer applications that do not fall within the usual information system concept but that may serve the manager in essential ways, and in these lie some of the greatest potentials. One that is especially provocative is simulation. Computerized models have been developed that allow the selection of a course of action running through ten or fifteen years of simulated operating experience before its effect is seen. If the model says the course of action is a good one, it may be advisable to adopt it. If the model says that it is a bad one, an alternative should be considered. As these models are used, they are refined and improved. Experience and experimentation disclose errors and, as these are corrected, the prediction gets better and better. Preliminary models of this type have been developed to help predict future urban land use.

It is important to retain perspective on the implications of computerization. One of the fields of endeavor in which computers have been most extensively applied is in science, where increasingly intimate interaction between scientists and machines has produced a tremendous impact that promises to grow even greater. Yet, while computers are being used by scientists to do many of the things they themselves used to do tediously, no one hears much of scientists being made obsolete by computers. In fact, the demand for scientists has increased to the point where their availability has become somewhat of a national issue. What scientists do, minute by minute, is no different from what they did before the computer age, but what scientists *can* do, year by year, is immensely magnified as a result.

Today's managers need all the facts and need them in time to operate most effectively. They need information to begin planning for the problems to be faced five to ten years from now. And they need to make the right decisions. Formerly, wrong management decisions were not fatal. Lever Brothers' decision to stay out of the detergent field and Ford's marketing of the Edsel didn't put these companies out of business. But today's computers would have helped avoid both of these costly mistakes. Except for scientific and military applications, computers are usually purchased for the huge savings they effect. McDonnell Aircraft estimates a savings of approximately $200,000 annually through automation of their purchasing cycle. Sylvania Electric will save $500,000 a year in clerical and inventory reductions by using rented computers. Nationwide Insurance Company is predicting a savings in excess of a million dollars over a seven-year period through automating their renewal billing. In addition to cost savings, increased speed and accuracy in preparation of reports, improved customer service, and improved control of business operations are all important contributions of computerization which has yet to realize its full potential.

With the computer's ability to retain and acquire great volumes of data, officials and managers will be able to make necessary adjustments for economic planning, administration of tax programs, automatic selection and control of audit and work load, transportation and land use, and public health. By 1980, three out of four United States citizens will be brought into metropolitan areas, and by phasing into computer operations now, public officials will be better prepared to cope with this huge shift in population and the information handling problems this movement will create.

Computerization will assist in planning for public health needs as coordinated with transportation, land use, and a host of other functions. Food and drug inspections are already partially controlled by automation. Systems have been installed to facilitate the operation of blood banks and document searches and retrieval of birth and death records. Computers are assisting libraries and other government institutions with information search-and-retrieval functions. Social problems are being attacked and solved by computerization. But in order to effectively apply the new techniques, tomorrow's manager will have to exercise imagination and analytical ability. He will no longer be able to methodically copy earlier procedures, but will recognize that automation is the main route to maximal effectiveness.

The important point is that computers enable man to solve his problems more effectively, whatever his field of endeavor. They provide the means for coping more successfully with the whole range of problems introduced by the complexities of modern civilization, with its accelerating characteristics, even as it contributes to that complexity.

CHAPTER

2

Elements of EDP

Computer Components and Concepts

On Line-Real Time Systems – 1964

ROBERT M. SMITH AND JOHN J. CONNELLY

Computer Components and Concepts

ITS FLASHING panel lights, the clatter of the printing mechanism, its sheer size, and, above all, the waves of comment, criticism, and praise it has received, make the electronic data processor seem an awesome and mysterious entity, as remote from humbler business machines as man from amoeba.

But the differences between the electronic computer and the desk calculator, the typewriter, the filing cabinet are more apparent than real.

Yet, at the same time, it is perfectly true that computers have already revolutionized business; even the firm that has never used one—and perhaps never will–has already been affected by the data processor. And, in the future, all business will become increasingly involved with and affected by electronic computing devices.

This paradox is explained by the fact that, while computers perform no single, individual action that cannot be duplicated by some other machine, they do have three characteristics which make them different.

1. They are capable of such fantastic speeds of calculation that, even though each computation they perform is relatively simple, the number of computations that can be made in a short period of time makes possible business applications previously completely impracticable–daily financial reports for a company operating across the nation, daily inventory reports, or sales analyses, for instance.

2. They have enormous storage capacity—they are in effect filing systems as well as calculators—so that needed information can be drawn on or filed—stored—at almost as great a speed as calculations are per-

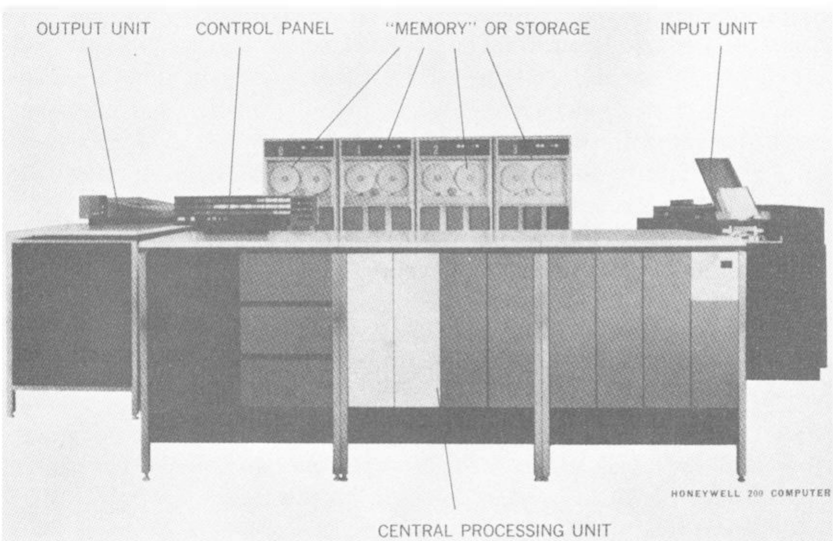
formed. By the same token, this immense storage capacity makes it possible to file entire sequences of instructions—programs—within the computer itself, so that at a given signal the computer can carry on long and complicated processing routines without human intervention or supervision.

Needless to say, the instructions themselves must be prepared by a human being before storage within the machine.

3. Since all computers incorporate "input" and "output" units, information flowing into the electronic data processing system need not be physically transported as it may be with punched card machines, for example. Once within the system, any desired manipulations of the data can be accomplished entirely by the system.

"System" is the key term. For an electronic data processor, even though the term is used as a singular, is composed of three distinct components: an input unit, the main computer, and an output unit.

The input and output units help to bridge the gap between man and the computer. The input unit provides the main computer with all the instructions and data that are needed to solve a problem. It translates data from the numbers and letters used in business into code symbols used within the computer system. The output unit, performing approximately the same type of operation as the input device in reverse, translates the results of the computer's processing into understandable form.



There is a variety of input and output media, such as magnetic tape, punched paper tape, and punched cards. Or output can be in the form of legible, printed words and figures. Cards and tapes are prepared on equipment which is designed to put ordinary language into form usable by the computer. When the tapes or cards have been prepared they are placed in input machines, readers, which read the data on the cards or tapes and simultaneously send these data to the main computer.

The main computer is the central part of the computer system. It is made up of three sections: control, arithmetic, and memory.

–The control section is used to coordinate and sequence the instructions and the data with which the entire system works.

–The arithmetic section is used to perform all the arithmetical and logical operations.

–The memory section is used to store instructions and data needed to solve a problem.

The control section establishes the timing sequences and controlling operations which are necessary to execute the computer's instructions. The instructions (or program, as computer personnel call it) are stored in the computer's memory. They give the computer explicit directions on what to do and when and where to do it. They determine that data be sent to and from memory and other data to and from the arithmetic section.

The arithmetic section is the nuts and bolts of the computer. Here are the circuits, transistors, and wiring that do the addition, subtraction, and other mathematical operations. Sometimes this is called the "logic" unit since it also does the manipulating and comparing of data.

The computer's memory is a vital part of computer hardware. It stores instructions and data and offers them for use whenever called for. Both of the computer's memories, internal and external, are quite like our own memories; i.e., they can store a great many facts but they do have limits. The human's external memory—books, dictionaries, almanacs, etc.—stores facts too innumerable to carry in one's head. The computer has an external memory that is also capable of storing thousands of times the capacity of its internal memory.

Communicating with the computer

Computers recognize only two numbers—one and zero. However, everyday business problems and data are expressed in ten digits—zero through nine—as well as letters and words. How then, can this information be fed into the computer so that the computer can recognize it and work with it?

Computer components, since data processors use electronic circuitry, can be in one of two possible conditions—"on" or "off," positive or negative, just as a live electric bulb in a table lamp must be in one of two conditions—on or off. If we designate one condition as 1 and the other as 0, we have the elements needed for a binary number system—which is the system used within computers.

The binary number system uses only two symbols, 1 and 0, in contrast with the ten, 0 through 9, used in the decimal system, and expresses quantities in powers of the base 2 as the decimal system does in powers of the base 10.

How binary notation works

In the decimal system there is a unit column in which 1 represents 1 (10^0); a tens column, in which 1 represents 10 (10^1); a hundreds column, in which 1 represents 100 (10^2); and so on. Similarly, in binary notation, there is a unit column in which 1 represents 1 (2^0); a two's column, in which the symbol 1 represents 2 (2^1); a four's column, in which the symbol 1 represents 4 (2^2); an eight's column, in which 1 represents 8 (2^3); etc.

It is perfectly possible to represent any decimal number by its equivalent in binary notation. Thus the decimal number 11 would be represented in binary notation by 1011.

The chart at the bottom of the page illustrates the concept.

One can easily see how this system works with a list of decimal numbers and their binary equivalents.

We are working with two symbols, 1 and 0, and a binary number system based on powers of the base. 2. All right, then, our basic number structure (in decimal figures) by columns is:

	$64(2^6)$	$32(2^5)$	$16(2^4)$	$8(2^3)$	$4(2^2)$	$2(2^1)$	$1(2^0)$
and our binary notation for decimal number 11 is then				1	0	1	1
the decimal value of which would be				8	0	2	1=11

Decimal	*Binary*
0	0
1	1
2	10
3	11
4	100
5	101
6	110
7	111
8	1000
9	1001

A decimal system 0 equals a binary 0, 1 equals 1, 2 equals 10 in binary notation, 3 equals 11, and as shown above a decimal 7 equals a binary 111. By expanding this table it is possible to see how any decimal number can be converted to a binary number which can be recognized by the computer.

This same logical approach can be applied to letters too. We normally think in the English language of twenty-six letters, A B C D E ... Z. These letters can be easily equated to decimal numbers. For example, A equals 1, B equals 2, C equals 3, and so forth. The word "BED" could now be written with letters "B," "E," and "D," or with the numbers 2, 5, 4. Converting these number to binary we can express the word BED in this manner, 10, 101, 100.

Since computers can be told when binary numbers are used to represent decimal numbers and when they are used to represent letters, it is understandable how letters and combinations of letters, which are words, and even sentences are fed into the computer in a form which it can understand.

Since almost all modern computers automatically convert the decimal numbers used for input into the binary systems used within the computer, and translate letters and operating signals into coded binary representation, binary numbers are an unnecessary worry for the accountant. Once he knows what they are, and his curiosity is satisfied, he can for all practical purposes forget about them.

A sample computer operation

Basically, in a practical business application, the three units that make up the data processor might work in this fashion. Let's suppose our computer's assignment is to update an inventory for a large company which must keep several thousand items in stock at all times at a central inventory control point. Let's assume, too, that the computer has already processed production figures and shipments just before the inventory processing so that the machine has stored in its memory the precise inventory level for every inventory item "on hand and on order" at the central control point at the beginning of whatever time period is to be used.

Now, inventory disbursement reports for the time period (which can be as short as a day) are fed through the input device into the system. The computer would act on the reports according to instructions, stored in its memory, which would be programed roughly as follows:

1. Read disbursements for day. If no disbursements, end program, proceed to next (inventory) item.

2. If disbursements have been made, go to previous inventory level, bring back figure for previous level. Subtract disbursement figure from previous inventory figure. Check result against desired maximum-minimum inventory level for item. If below minimum or above maximum, print out message. (For management action, under management-by-exception principles.) If not, eliminate old inventory figures, store new inventory figure in memory, end program. Go to next item.

And so on through every inventory item the company must stock.

This is a greatly oversimplified version of what the computer does. Actually, a great many more instructions than this would be necessary for even such a simple program as the one given. And a more elaborate program, in which the computer, on updating inventory levels, automatically calculates production schedules to satisfy inventory needs, and even prints out raw material orders in terms of the production schedules specified, would require extremely detailed instructions.

Given such a program, the computer can make decisions—of the "If this, do this; if not, do that" type. It is the complexity of the application that determines the complexity of the computer program. The machine itself can perform only the simplest individual actions; it may multiply by repeated additions; it may subtract and divide by using complement addition. But its power lies in its ability to do hundreds of thousands of such simple calculations every second. Many short cuts which mathematicians have known for decades are completely beyond its powers, but it can still solve the most complicated mathematical problems at far greater speed than any human—as long as a human has devised the program to be followed to arrive at the solution.

What is a program?

A program is a set of computer instructions made by a programer. The programer is a kind of supervisor of the computer. He must be able to visualize an entire program-problem, and break it down into its logical parts or functions, one of which would be the sample problem. He must be able to understand the capabilities of the computer and translate the logical steps of the problem-solution into a set of instructions, or a program for the computer which is stored in the computer's memory. The ability to follow the instructions set down by the programer, to progress step by step through any portion of any stored program, thereby producing the desired output without direct human supervision, is the essential characteristic of a computer.

RICHARD E. SPRAGUE

On Line-Real Time Systems – 1964

SEVERAL YEARS AGO a prediction* was made concerning on line-real time systems. Enough new evidence has been accumulated to examine the prediction and to test the thesis underlying it.

An attempt was made in my book (*Electronic Business Systems,* Ronald Press, 1962) to formulate a thesis which would explain the trend toward On Line-Real Time (OLRT) systems. The skeptics and the economists when made aware of the trend usually comment on the high cost of OLRT mechanization and ask how any organization outside the military or airlines or savings banks would be able to justify the cost.

This is a very pertinent and legitimate question which every organization ought to ask itself before proceeding to an OLRT system. The answers, in general, do not begin to explain the trend. One must dig deeper into the very nature of data processing, business systems, and the way an organization is operated and managed to find the explanation.

The thesis, and the resesearch work behind it, did just that. As a result, the trend toward OLRT can best be explained by reversing the skeptic's question to ask, "Can we afford *not* to have an OLRT system?" This should be expanded a little. The thesis implies that for most larger organizations to be managed and operated in the manner

** In 1962, in his book, "Electronic Business Systems," Ronald Press, Mr. Sprague predicted that, "by 1970 nearly all electronic data processing systems will be of an On Line-Real Time variety."*

which most advanced business systems groups advocate today, the information, storage, processing, communication, decision making, and display requirements *can not* be met by batch processing methods.

OLRT systems provide the only feasible solution to meeting the requirements available today.

For the smaller organization as well, OLRT systems are the only feasible type to meet the requirements generated by the necessity of sharing systems among small users in order to compete for business. In the long run, when enough subscribers share an OLRT service, the costs are bound to be lower and justification will be easier.

So, it is not sufficient merely to ask, "How can we justify an OLRT system?" It is essential that the basic pressures and reasons for the present trends be explored. *All* of the information needs for an *entire* organization should be determined. *Then* a decision can be made as to whether it is possible to accomplish the company's objectives over the next five years with batch processing techniques or whether the organization must go to OLRT.

After re-examining the thesis and evaluating new evidence, the author's prediction is still that batch processing will fall short of meeting the needs of most organizations and that nearly all business systems will be of the OLRT variety by 1970.

Before attempting to present and evaluate the new evidence and developments in OLRT, it seems desirable to orient the reader by defining the term, OLRT system, and by giving a short description of the thesis behind the prediction.

In a total OLRT system each and every person, machine or point (point of origin) in the organization using the system, having a true requirement to originate, retrieve or utilize information, is provided with a point-of-origin device (POD). These devices are connected to a central data processing complex by wires or other direct communication links (see Fig. 1, on page 24).

Each device permits two-directional information flows at a point of origin of information such that the person or machine using it receives responses to his requests (when a response is required) in the amount of time desired. This, obviously, implies that all information with which every person or machine must deal is stored in some mechanized form immediately accessible to the data processing complex, and that all files of such information are connected *on line* to the complex.

The total nature of the system is brought about by the fact that *all* information for *every* person from the chairman of the board down to the lowest clerk is inserted and is available through the point-of-origin devices. This means that *all* information for all system functions is processed and stored by the system.

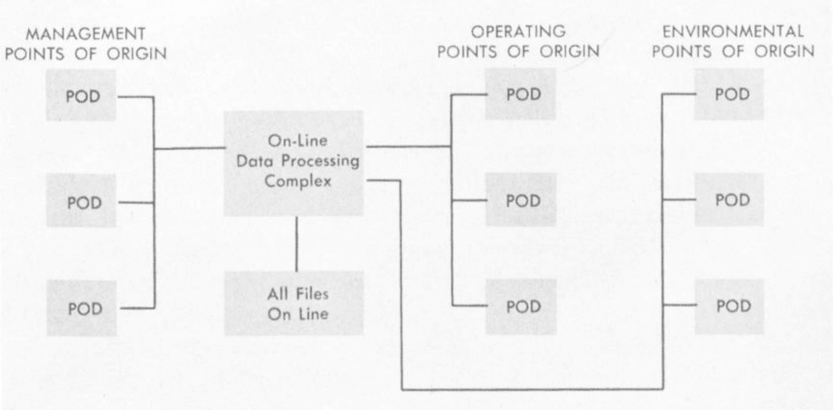
In addition to persons, machines, and points within the organization, it may be desirable in some cases to go outside the organization to the true original source of information generation and place point-of-origin devices in the environment of the organization (see Fig. 1).

The thesis can best be described by referring to Figure 2, Thesis Diagram, (page 25) which illustrates by arrows that fundamental economic and total-systems pressures lead to a set of requirements which, when coupled with technical developments, in turn lead to systems that have the characteristics of OLRT systems.

These pressures have existed since the beginning days of the data processing industry. The requirements have also existed. The technical developments have, however, just emerged since 1958 or 1959.

Long-range planning. Returning to the discussion of how to decide whether an OLRT system should be considered, many companies have already been through the soul-searching, overall business systems planning efforts implied earlier. Top and middle managements have suddenly found themselves embroiled in their information systems executive's plans and vice versa. In almost any large company or government organization which has been through this soul-searching, the OLRT system has been talked about.

Figure 1



Total OLRT System Diagram

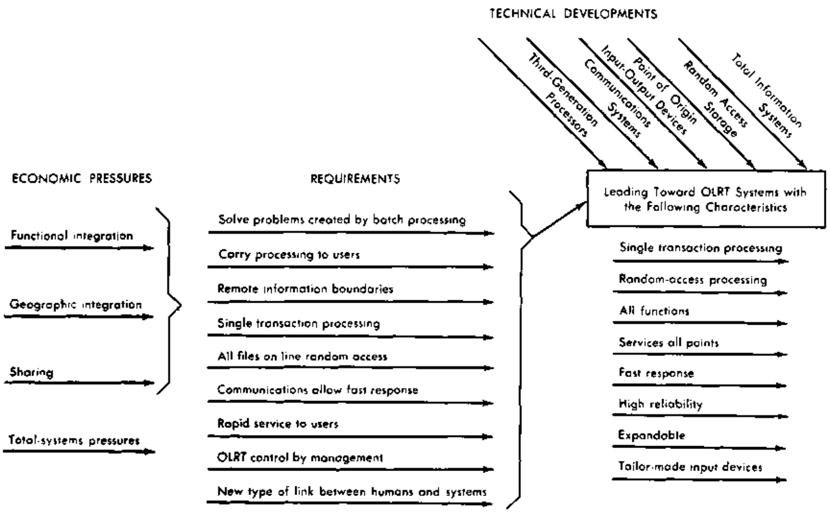
The "new look," however, is to consider OLRT as a potential long-range goal for the entire corporate business system. The business system plan may involve several steps or phases along the way toward the goal. Some of these steps, as in the case of the airlines and savings banks, may include OLRT mechanization of selected functions. Included in the long range plan may be such functional areas as: business systems, manufacturing process control, communications switching, central information retrieval and library systems, management control centers, and centralized engineering computation services.

While these have traditionally been considered separate problems and systems, each of them generates a requirement for OLRT techniques. As a result, the long-range plan may well incorporate two or three or even all of these functions in the same OLRT system.

The number of OLRT systems installed, on order, or in the planning stages by industry was reported in *Electronic Business Systems* in chart form. Figure 3, page 26, shows the list of industries and indicates several new ones. The growth in OLRT systems has been caused by both the increase in numbers in each industry and the addition of new industries.

The column labelled Process Control in Figure 3 indicates those in-

Figure 2



Thesis Diagram

dustries with OLRT systems installed for process control applications. *Control Engineering* magazine in the September, 1963 issue listed 340 process control systems using digital computers installed throughout the world with 237 of them in the United States. For the purpose of this article, the process control situation is considered important because of potential relationships to business systems. This will be discussed later in the article.

New industries. Figure 3 lists a number of new industries. Typical of these is the insurance business.

Figure 3

INDUSTRIES WITH OLRT SYSTEMS

Industries	New in Last Two Years	Process Control
Federal Government		X
State and Local Governments	X	X
Airlines		
Savings Institutions		
Commercial Banks		
Insurance Companies	X	
Radio and TV	X	X
Telephone Companies		
Service Centers	X	
Hotels		
Universities	X	
Hospitals	X	
Stock Brokerage		
Railroads		
Public Utilities		X
Retail and Wholesale		
Manufacturing		
Electrical		X
Cement	X	X
Petroleum		X
Chemical		X
Metal Industries		X
Large Equipment		
Paper		X
Aircraft		
Automotive	X	X
Publishing	X	
Doctors, Dentists, Lawyers, etc.	X	
Atomic Power	X	X

Insurance companies were among the first to utilize electronic data processing and have continued to be one of the largest users of EDP outside of the Federal government. However, they had not taken an active interest in OLRT until 1962. In a cursory examination of insurance company data processing requirements, all activities seem to be inherently batch processing in nature. No requirement seems to exist for rapid response to inquiries.

However, the insurance company's more detailed analysis with overall management and customer service considerations included shows a great justification and necessity for OLRT operation. As a result of this re-examination of objectives and requirements in (1962-1964), OLRT systems have suddenly become Topic A in the insurance field. Large numbers of companies are actively studying the possibilities, some have placed orders for equipment and nearly every insurance EDP conference has OLRT on its agenda. Allstate, Travelers, Equitable, and Metropolitan have announced OLRT plans.

Among the old active industries are:

Airlines. The airline reservations market for OLRT is rapidly becoming saturated. Nearly every good-sized airline has a system installed or one on order. The smaller carriers in the United States are examining various possibilities for sharing systems. Foreign airlines have recently contracted for systems, some of which will be world-wide in scope as will the new PANAMAC system of Pan American.

The larger airlines are moving ahead with plans for OLRT mechanization of related functions in the operations and accounting areas. At least one airline has announced that their system will encompass all functions on a worldwide OLRT basis.

While some problems and delays have appeared in the various passenger record systems under contract, the leading airlines fully expect to surmount them and to have reliably operating systems by the middle or the end of 1964.

Savings institutions. This industry, which includes savings banks, savings and loans, and the savings departments of commercial banks, is also moving rapidly in its use of OLRT systems. The situation has been accelerated by several new developments. The first was the announcement of the availability of new lower cost equipment and services. The second was the decision on the part of the Savings Bank Trust Company in New York to offer an OLRT savings service to savings institutions in New York City and State.

The third was the interest taken in OLRT by the Federal Home

Loan Bank which is considering the possibility of offering OLRT service on a regional basis to its many savings and loan members.

The fourth factor has been the success of the first OLRT system at the Howard Savings Institution. The Howard's management use of the system and the effect on the methods of banking, floor design, branch planning, etc., emphasizes the point that fast response to inquiries, such as airline and savings bank customer queues require, is only one of many requirements met by OLRT systems. Far more important in the long run will be the improvement in management control of the entire organization and effects on planning through the use of an OLRT system.

The fifth factor has been the grouping together of smaller savings and loans in several metropolitan areas around the country to consider sharing OLRT services. Among the active communities are Minneapolis; St. Louis; Kansas City; Worcester, Massachusetts; Rochester, New York; Detroit; Pittsburgh; Los Angeles; Philadelphia; Seattle; and Dallas.

To take an industry by industry review:

Federal government. The Federal government's use of OLRT systems continues at an ever-increasing pace. One new trend is the interest on the part of the Department of Defense controller's office in an overall total system for what is usually called the logistics side of the Department. Much of such a system would of a certainty be OLRT in nature.

State and local government. Several state and local government agencies have taken an active interest in OLRT. Examples are: State of New York—Division of Employment, California and New Jersey Employment Divisions, New York State and California Criminal Intelligence Application, Central Indexing for Welfare in New York City and Alameda County California, New York City and State Racing Commission Off Track Betting, and Process Control Systems for Auto Traffic Control in Detroit and Toronto.

Commercial banks. A few commercial banks have installed OLRT systems for processing savings accounts, or handling inquiries on commercial accounts. Most notable among these are the Manufacturers Bank in Detroit and the First National Bank of Chicago.

However, the trends in commercial banking are taking some other interesting turns. First is the trend toward offering EDP services to depositors, correspondent banks and other customers. As systems and customer service requirements are examined by these banks, it becomes obvious that today's MICR, batch processing oriented, EDP systems are not able to do the job. This is especially true as applications and services get further and further away from the demand deposit and transit functions.

One example is the U. S. National Bank of Omaha, Nebraska. It is providing doctors in the area with what amounts to a semi-OLRT service for patient accounting and billing. As far as the doctor is concerned, the service is OLRT because he is linked to the bank via Bell system Dataphone and his nurse can enter patient and treatment data at any time through a Dataphone card reader and keyboard in the doctor's office.

This type of service is also being offered by other organizations as will be described later.

A second trend in banking is the sharing of systems by groups of banks in an area. The same pressures mentioned in the thesis (and in more detail in *Electronic Business Systems*) will cause these groups to consider OLRT as opposed to shared batch processing systems.

A third trend is toward OLRT for over all bank management and customer service reasons. The same requirements that stimulate the insurance company, namely, a need to handle all customer accounts and relations at one time while the customer is in the bank or on the phone, also push a commercial bank toward OLRT. In fact, almost any organization which has a multiplicity of relationships with its customers will find customer service greatly enhanced by this feature.

Finance companies, savings and loans, and eventually retail organizations will fall into this category.

Radio and television. CBS and NBC both have OLRT process control computer systems installed for program switching. The toll TV companies have been interested in OLRT systems for measuring listener response, for collecting fees, for billing and advertising purposes.

Telephone companies. Several of AT&T's subsidiaries have made great progress toward total OLRT systems. Most notable of these is Michigan Bell where OLRT mechanization is quite far along. As implied in *Electronic Business Systems,* the entire telephone network is a giant OLRT system for voice and data communications. The Michigan Bell system also places the customer billing, accounting and other business systems on an OLRT basis.

Hotels and hospitals. Rather amazing trends are developing in hospitals. Not only patient services, accounting and accounts receivable are going on line. The patient himself is going to become part of an OLRT system at Children's Hospital in Akron, Ohio, and at the Veterans Administration. Measuring instruments will connect him to a central computer which alerts doctors and nurses when critical conditions develop or when it is time for specific action. Jefferson Hospital in Philadelphia is not going that far. However, they will install an OLRT patient accounting and billing system.

The hotel guest accounting and reservations systems discussed in the trade two years ago (which would seem to resemble the hospital system) have not progressed as rapidly as expected. Cornell University, the Statler Foundation, a group of seven hotels in New York and Sheraton Hotels have continued to investigate OLRT systems. Sheraton experimented with a new OLRT guest accounting system and to date has the only operating OLRT reservation system.

Stock brokerage field. Stock exchanges and stock brokerage companies have moved rapidly toward OLRT services and systems. Three types of systems are involved. The first is the stock exchange system itself. The second is a system employed by one or more national brokerage houses for customer accounts, and the third is the type of system providing information to brokers on stock prices and transactions.

No developments toward merging of these three types of systems have been detected to date.

There are three competing OLRT services being offered in the stock price display and inquiry area. Most large brokers have signed up for one of these and display techniques include quotation boards, lighted numerals, cathode ray tubes, printed strips of paper, and voice responses over a phone from a computer.

The New York and American Exchanges are both installing OLRT systems and others are actively interested. Several national brokerage firms have studied OLRT systems for customer service and accounting. F. I. duPont & Company is installing a system for switching messages from offices around the country to the floor of the exchanges, to the customer data processing center in New York, or to over-the-counter operations. Automatic logging of accounting and billing will be part of this system which in effect puts a customer directly on-line to the trading floor.

Railroads. A few of the railroads, notably the C&O and the Pennsylvania, have been experimenting with communications-oriented informations systems for some time. The key to breaking the log jam in railroad EDP systems for freight accounting has been the development of a reliable, inexpensive method for detecting the location and identity of cars. The jam may be about to break as the Association of American Railroads has agreed on a car reading technique and is entertaining proposals for its mechanization in an on line-real time fashion.

The concept is that optically scanned plaques fastened to the sides of cars will feed identity data into systems allowing both car location and inter-road accounting, as well as operational controls to be realized on an OLRT basis.

Public utilities. The bulk of OLRT interest on the part of public utilities has been in the use of process control systems for the control of electrical and atomic power. Certain utilities would like to see a low cost point of origin device developed for OLRT meter reading and utilizing existing power lines for data communications. The resulting customer accounts receivable and billing system can be visualized as having many advantages over current systems. This still appears to be a long way off.

Retail and wholesale. Only one type of system has been developed for retail stores using OLRT techniques. Only two stores have put it into operation. Robinson's in Glen Burnie, Maryland, and Kaufmann's in Pittsburgh. The rest of the industry seems to have adopted a "wait and see" attitude. It is not a complete computer-based system, which may account for some of the waiting.

Meanwhile, grocery chains, mail order houses, and other types of retail chains have been studying OLRT techniques. None has made any announced commitments to date.

Manufacturing industries. Possibly the third or fourth greatest level of progress (after airlines, government, and savings institutions) toward OLRT systems in the past two years has been in the manufacturing industries. Some of the impetus has been caused by the influx of process control systems and some by each of the general factors yet to be discussed. In any event, electrical, petroleum, chemical, metals, paper, aircraft, and aerospace, automotive, and other process industries such as glass, cement and rubber manufacturing have all taken a very active interest in OLRT systems.

This list of companies includes: Westinghouse, Socony Mobil, DuPont, U. S. Steel, Mead Corporation, Lockheed, and Chrysler, just to name one from each industry. Applications usually include production and inventory control, scheduling, customer order processing and quotations, factory data collection and management, and general management controls. Not one of the manufacturing companies involved would claim to have a total OLRT system installed. Too many links are missing in point of origin devices and much, much work yet remains in systems design and programing. However, the most advanced of the companies *would* claim that OLRT fits into their long-range planning picture in goal form as outlined in the introduction.

Three general trends

Three new general trends are creating pressures for OLRT in manufacturing industries as well as certain other organizations. They are: Management Control Centers, Combined Process Control and Business Systems, and Remote-Shared Engineering Computation.

Most of the computer manufacturers are developing or have developed display devices or techniques for military use which are now beginning to be applied (or at least sold) for commercial use in what has come to be known as a *Management Control Center*. One aerospace company has included a description of an MCC and a mock-up design in a movie made about its own management information systems.

The concept of an MCC is that top level management meeting in small or large groups in the center can have displayed before them in various forms current operating and financial information. Selections are made from a management console and information concerning decisions as well as inquiries can be inserted as the meeting progresses.

The assumption that must be made if an MCC is planned is that an OLRT lies behind it. The data and management information to be useful must be retrieved while managers are in the center. The greatest advantage of such a concept is the tightness of control which can be exercised by management and the conserving of management's time.

It is possible that an entirely new science may be emerging which combines the informational and psychological fields. It is the science of presenting information to executives, making them understand it and retain it and finally allowing them to communicate decisions which they understand back to an organization *through* a system.

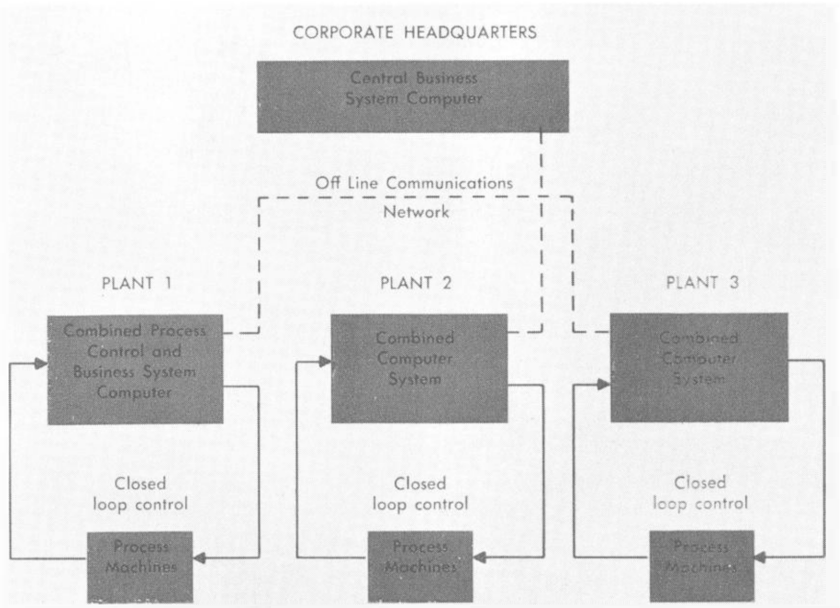
Much work remains to be done to develop this new science, if it can be called that. More is implied here than that which industrial designers and military systems planners have called man-machine relationships.

Combined process control and business systems. The second general trend is just beginning to emerge. It is the concept that digital process control systems and computer-based business systems have enough interrelationships between them to begin considering combined systems designs. Two possible relationships are worth considering. First, if a single central computer complex is capable of handling both a process control application and a major part of the business system of an organization, it may be more economical to use it than two separate computers.

The answer to this depends on the geography of the organization, i.e., number of process control plants and where located with respect to the corporate center, on data communications facilities and costs, on the type of process control involved, and on the amount of business system data processing to be done at each plant location. Figure 4, below, shows a multiple plant company with combined systems at each plant and Figure 5, page 34, shows one large central computer doing the entire job.

The second relationship is more subtle and depends on the nature

Figure 4



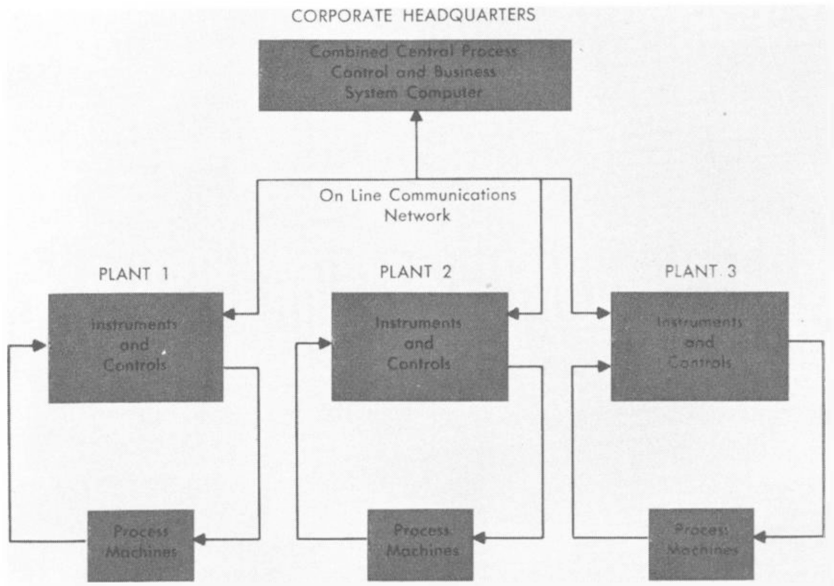
**Multiple Plant Co.
Combined Systems at Each Plant**

of the manufacturing process. It is the probability of system overlap between the two areas at two points. The production scheduling and control output of the business system is bound to affect the input and environment of the process control system.

Also, the outputs from the process control system will probably form some of the raw production status data for the business system. These relationships can become quite complicated depending on the products being made and the ways in which they are produced, packaged and sold.

For example, postulate a paper manufacturer with several paper machines, several cutters and packagers in one plant, all under control of a digital process control computer. The production scheduling and control part of the company's business system must keep track of what paper (grade, color, size, etc.) is being and should be made on each machine, and how it is being and should be cut and packaged. But, so must the process control computer do all of these things in this

Figure 5



Central Computer Combined System

hyper-system. It is apparent that in these circumstances, one combined system is dictated.

The *pressure* referred to earlier, which may bring manufacturing companies in the process industries to OLRT systems earlier than otherwise, is that of economic considerations such as the ones given above plus the tendency to place all digital computers in the organization under the same type of systems design structure.

Remote-shared engineering computation. The third development affecting manufacturing companies is in the engineering and scientific sphere. In most large companies where research and engineering play an important role, electronic computers have been in use for several years. The trend in the past has been toward the use of smaller and smaller-scale machines by individual engineers or groups of engineers and scientists. This is primarily due to the nature of problem solving using a computer. It is a trial and error process in which the engineer communicates back and forth at more or less non-scheduled times with his computer. Program as well as data changes are made as the solution progresses.

Now, it has long been established that the larger and faster the computer, the more efficient it becomes and the less expensive is the unit of computation per unit of time. The economic pressure then exists for engineers and scientists to share a large computer rather than use many small ones. The problem has been how to share and still retain the kind of personal relationship an engineer develops with his own little computer.

M.I.T. and Systems Development Corporation have been experimenting with OLRT solutions to the problem. By providing an engineer with a properly designed console connected on line over communications facilities to a large scale computer, the equivalent of his own little computer in the same room can be provided. Many engineers can time share a large scale computer on this basis, provided a suitable executive control program is used in the computer on an OLRT basis.

SDC and M.I.T. demonstrated the feasibility of such a system in November, 1963, when an engineer at M.I.T., using a teletypewriter linked by telephone lines to SDC's large-scale computer in Santa Monica, California, shared the machine with six other engineers in California, all working on their own programs. To each one it appeared as though the entire computer facility was at his disposal. In this first trial program changes were required to be entered by a consultant at the computer site.

As this concept spreads among larger manufacturing companies, another pressure will be created for OLRT systems. Socony Mobil Oil Company already utilizes its business system computer center in New York for remote-shared engineering computation on an OLRT basis from locations as far away as London and Seattle.

Also, the concept should lead to the establishment of OLRT service centers for engineering and scientific computation. It is possible that some of these will be owned and operated by universities and non-profit organizations like SDC.

One new "industry" trend, if it can be thought of as an industry, is the offering of OLRT service to small businessmen such as doctors, dentists, lawyers, small stores, etc., who do business on a credit and billing basis. The earlier section on commercial banking mentioned this type of service as being offered by a midwestern bank.

Organizations of other types are springing up all over the country with similar OLRT services. In Alvin, Texas, a public accounting firm[1] handles doctors and other clients located in medical centers in the community. In Los Angeles a service company[2] offers OLRT service using Dataphone to doctors and dentists. Also, Bank of America in California and some other banks provide this service.

In Boston, another OLRT service bureau[3] is doing work for small manufacturing companies, a hospital and a factoring company.

The economic attractiveness of OLRT services for small business lies in the ability to eliminate any need for clerical help and to enable the doctor or dentist to concentrate on his patients without worrying about accounts receivable, billing and collecting.

Dataphone. The role of AT&T's Dataphone service in these small client OLRT service centers cannot be overlooked. Every doctor, dentist or lawyer has a telephone. The same phone will be used for his OLRT service. A small card reader is attached to it. The line charges are negligible if he is in the same metropolitan area as the center, since they are based on the use of the same lines as his voice calls and the same rate structure.

It is the attractiveness of the Dataphone concept which seems to be stimulating many of the OLRT service centers. The doctor never leaves his office for reporting or record-keeping purposes. His nurse can enter the data in her spare time. The bills go directly from the center to the

[1]*Kennedy, Sheppard & Co.*
[2]*Telecredit, Inc.*
[3]*Key Data, Inc.*

customers so the doctor never sees them unless he wants to. Even the payments and deposits in the bank to the doctor's account can be handled without his attention if he so desires.

As pointed out in the thesis, new hardware developments have a strong influence on the rate at which OLRT systems can progress with economic justification.

Developments in the past three years have accelerated OLRT systems in several industries and applications.

The most general new hardware development has been the announcement of the availability of lower cost computers with OLRT characteristics. Nearly every computer manufacturer has now announced at least one OLRT-oriented computer and the majority of new machines are equipped with some OLRT features.

The new computers include the IBM 1440, 7040, 7044, Univac 1050, NCR 315-100, Honeywell 1400, G.E. 400 series, RCA 3301, and SDS systems. In addition, standard lower cost computers such as the H 200, the B 200 series, the RCA 301 and the G.E. 200 series have been adapted for OLRT use.

The new IBM System/360 is specifically designed for total On Line-Real Time Systems. The computing equipment, communications equipment, point of origin terminal equipment, and a hierarchy of on line storage devices go along with the system. This array of hardware should focus the attention of many IBM customers on the possibilities of On Line-Real Time operation.

Process control computers and communications switching computers with OLRT characteristics were also announced for sale in large numbers.

The cost of large volumes of random access storage has been a limiting factor in economic OLRT systems for many applications. The introduction of RCA's RCA 3488 memory with a per character cost lower by an order of magnitude than prior mass memories should have drastic effects on the economic situation. The 3488 memory uses magnetic cards for storage, can be as large as 5 billion characters and has a cost per character lower than magnetic tape.

A second limiting factor has been the rather high access time of mass memories for a reasonable cost. The new Burroughs disc file with 20 millisecond (a factor of five below others) access time and costs comparable to prior memories provides a solution to this problem.

Other memories include the IBM 1440 disc pack, and the 1302 disc file and the Univac Fastrand.

Data gathering equipment for manufacturing companies has been brought out by several computer suppliers. These include RCA's EDGE, G.E.'s Datanet, IBM's 1050 series, NCR's offering of Stromberg Carlson's equipment and Data Trend's MIMO (a handwriting device).

NCR, G.E., RCA, Ramo Wooldridge (now Bunker-Ramo Company), Burroughs, IBM, and Univac have all developed types of management displays ranging from complete wall projection to image retention type (NCR) consoles.

Teleregister has also data display devices, one for use in the stock market inquiry field, and the other for general purpose inquiry and display applications. Both use inexpensive cathode ray tubes.

Except for specific industries such as airlines and savings institutions, no pattern seems to be emerging in the use of Point of Origin devices or displays.

The majority of the communications services and facilities for OLRT available today (1964) were also available two years ago. AT&T's services, Dataphone, WATS, Telpac, and Dataspeed WADS, have had the major impact on OLRT systems planning. However, Western Union, RCA, IT&T, Collins Radio, and others have also provided data communications facilities for OLRT systems.

Education. Orienting, training and educating engineers, programers, systems designers and management in OLRT systems lagged behind developments until recently. Now, special courses and seminars are conducted at many universities and companies on the subject. In addition to the computer manufacturers, notably IBM in its Systems Research Institute, M.I.T., University of Pennsylvania, Carnegie Tech., American University, University of California and University of Chicago all hold OLRT courses.

Software. The software gap in OLRT systems has been described in an article[4] by a former OLRT systems engineer and programer. What most organizations with experience in the field have learned the hard way is that OLRT programing and software are very different from batch processing. "Old timer" batch processing programers sometimes make the worst OLRT programers because of the major differences in philosophy required.

Today a small cadre of OLRT programers coming out of military, airline and savings institution areas form the best knowledgeable core of experience available. Unfortunately, until education and training catch up, this number is pitifully small.

Systems and programing talent may well be the greatest limiting factor in the growth of OLRT systems.

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[4] *R. V. Head, "The Programing Gap in Real-Time Systems," Datamation, February, 1963.*

CHAPTER

3

The Computer and the Local Practitioner

What the Computer Means
to the Accounting Profession

Computer Service for Clients

Low-Cost Computers Help
Small Firm Grow

Expansion of
Service Center Operations—
A Case History

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What the Computer Means to the Accounting Profession

THE COMPUTER presents two sides to CPAs: a side that threatens our existence as a profession and a side that promises dynamic opportunity.

The computer confronts us as a profession with a situation as basic as the discovery of nuclear energy. If we don't master the computer, it could destroy us. If we do master the computer, it will give us an abundantly creative instrument with which to work. But whatever we do with it, things are never going to be the same again.

I strongly believe that unless we overcome the *threat* of the computer, we shall never have a chance to realize its opportunities.

I would like to cover four basic points as they relate to this problem:

First—the threat itself

Second—the opportunities. (Here I would like to present specific examples of services we are already performing for clients on our EDP equipment and some exciting potentials for new services.)

Third—some of the basic economics of computer practice

Fourth—the responsibility that we have to the business public, our staffs, and to ourselves as professionals

The banks, the service bureaus, the manufacturers and others who have entered the financial reporting and advisory fields are not just providing perfunctory write-up services, but often fairly sophisticated levels of management services.

These agencies provide package programs for financial management, which inevitably involves them in making choices on principles of accounting. Service centers are offering to convert present systems of accounting, such as are now set up in our clients' offices, to computerized systems. Clearly, these service centers are engaged in systems work—and they don't charge for it.

It's possible that in the future these service centers will add systems specialists to their staffs, including CPAs—and that they will use as a cogent sales argument the desirability of having the systems design work performed by those who own or control the hardware, of having systems specifically designed around the configurations of their own machines.

Atrophy could afflict the profession if CPAs become less and less engaged in this systems design work.

The attest function itself may also be vitally affected. An automated system generates more information, and faster, than the accountant can by wading through papers to prepare analyses of his client's accounts. The computer can automatically prepare balance sheets and income and expense statements, *both fully backed up* with detailed listings such as agings of receivables and payables, expenses, etc.

How much auditing will the client want for himself when he can see all the details of each account?

How much auditing will the banks insist on, if they themselves are preparing the data—especially when their systems will automatically provide a listing of all the components in an account?

Conceivably, the services provided by these agencies could destroy our local firms by taking over the lion's share of accounting work for all small and medium-sized businesses. Loss of these clients, which provide a substantial share of the national firms' revenues, would hit even the largest CPA firms with a crippling blow.

These threats make the computer sound like a potent machine.

What makes this machine so powerful an accounting implement—either for us, or for the other agencies who may utilize it?

We all know computers can add, subtract, multiply, divide and print—but so can many other accounting machines. The computer has more important capabilities that separate it from the posting machine category—capabilities that are all important to us as accountants and that make the computer an effective tool in our professional work.

This paper discusses the computer as a means of marrying two talents in our professional work—the marriage of management services with financial reporting.

Physically, this is what the computer can do:

The machine has a tremendous capacity to store information in its memory for subsequent recall. It can store in its memory such elements as price lists, cost factors, rates, descriptive data, equations, and sequential order of working with that data. And the computer will carry out programed instructions and print out the results at speeds that start at rates of 400 to 500 lines per minute.

Computers, once programed, can relate financial information in an infinite number of ways, far more effectively and with greater speeds than we, as accountants, can do it.

Computers have the ability to make calculations without the need for reprocessing cards, as was necessary under earlier types of tabulating equipment.

They can perform a sequence of operations without the input of new cards or tape to activate new calculations. Results obtained are held in abeyance pending further calculation. The information may be retained by the machine until further call, according to the programed instructions.

Under the conventional written system, because of the limitations of distribution columns, we normally recorded the amount of the transaction without all the collateral information. In order to analyze the different functions and facets of a business, we had to search through the files and through the basic records for much of the information that is provided for us automatically under computer systems of accounting.

Under computer systems, we may analyze sales separate and apart from the other functions of the business without scrounging through files and original records. We can separate sales by employee, by geographical area, by department, by product.

In studying labor costs, we can examine labor costs per hour, per unit, per classification of labor; we can analyze whether it is seasonal, fixed, etc. If we place in the machine's memory constant factors of cost and then later place the operating variables—as these variables become known—an infinite number of operating relationships may be developed and studied. Just think what opportunities this offers to CPAs in the future—to be able to obtain *currently* the basic data which are so necessary for management analyses.

By recording financial data with all the collateral information such as quantity, types, descriptive material, etc., we are able to record a financial transaction in its full environment for later retrieval. By recording transactions in terms of their lowest common denominators, we can correlate factors according to cause and effect relationships that exist in business situations. We can relate hours worked to labor costs, production units to manufacturing costs—all as a routine rather than an exceptional procedure.

It is *not* the ability of the machine to write up volumes of information with great speed that is important to us as professionals; this is a negligible aspect of computer operation as it relates to us. Rather, the computer affords us the means of carrying out many sophisticated, new, creative ideas in management services.

And if, when we are designing systems, we are able to anticipate factors that are important in solving problems, we can build these factors into the system, so that later they can be retrieved with minimum cost to the client—and these factors will be of tremendous importance to us in doing creative work for the client.

The type of information that we seek and what we do with it is limited only by our imagination and our resourcefulness.

A few examples of work being done by computers today (and remember, this is probably kindergarten work compared with the work that will be done in the next few years) will give an indication of how the computer can be a boon to the profession.

Payroll job. Preparation of a payroll, with all its attendant records, is a time-consuming but routine job for all companies today. The total payroll job can be performed by the computer. And if we add the slight additional input information of how the employees spent their time during the day period, the computer can correlate this with production data and give management valuable cost and efficiency analyses.

To set up the basic payroll preparation job on the computer, the complete environment of the employee's pay and all the collateral information about him is fed into the computer's memory by means of punched cards, paper or magnetic tape. This information would include the employee's name, address, identifying number, base pay, overtime rate, premium pay, deductions, number of tax exemptions, method of computing unemployment tax, and other factors about pay and deductions. The same type of information is stored for all employees.

After the computer is fed the employee's weekly hours worked and his identifying number, it searches out his name and number and calculates his base pay, overtime, premium pay, total pay, withholding tax, unemployment deductions and other deductions and figures his net pay. It also updates this information and prints it out in a statement.

If the employee is paid by check, the computer writes the check in full, ready for signature—if in cash, it figures how many $20's, $10's, $5's, and coins are needed.

But suppose not only the total number of hours an employee worked during the week was put into the computer, but also the time spent on different operations in a 48-hour work week. For example, if the employee worked 20 hours on operation A, 18 hours on operation B, and 10 hours on operation C, the computer could determine the rate per hour by computing the total pay and dividing by the number of hours worked during the week. By multiplying the hours worked on different operations by the cost per hour figure, the computer could print out, at the end of the payroll, the cost for each operation.

If the hours worked on these different operations, according to different locations or branches of the company, were fed into the computer, data on operational costs per branch would be printed out. If productive units were introduced into this calculation, data costs per productive unit, per branch, per operation, and so forth would turn up.

The payroll job gives a good example of how you can take a routine task, add a little forethought as to what cost relationships may be significant, and produce reports as simultaneous by-products which have real value to management.

Budget accounting. Budget accounting is another example of a computer application. The title of the budget accounts and the dollar amount of the annual appropriation can be stored in the memory unit. During the period under review, charges to the accounts are recorded not only in dollar amount, but with all the peripheral information relating to that dollar amount.

When preparing a periodic budget report, the computer lists the title of the budget account. In the first money column the amount of the appropriation is shown, in the next column the amount expended to date, and in the next column the unexpended balance. If the transactions of the preceding year are programed, the machine will then compare the unexpended balance remaining for the current year with the amount actually expended during the same remaining months of the preceding year. For example, if a report for the period ended July 31, 1965, were running, it would show the budget account title, the amount of the appropriation, the amount spent for the seven months ended July 31, the unexpended balance left in the appropriation account, and the amount expended from August 1 until December 31 of the preceding year. In this way a measure of the adequacy of the unexpended balance —by account—is obtained.

Furthermore, many of the budget accounts as shown in the summary report are broken into subaccounts in a detailed report, so that it is possible to highlight the financial condition of each budget component.

In addition, the machine may list in full detail the descriptive matter in full support of each charge in the respective budget accounts. Copies of these reports are then distributed to the individuals responsible for the expenditure of funds.

This type of report makes additional auditors of the people who are responsible for the expenditure of funds. It places information that normally would be lost in the records up on the table for management to see—and at the proper time.

It brings to bear on a problem the vast storehouse of collateral information that management knows about the transaction, not just the cold final-figure results.

Inventory control. Inventory is the heart of many businesses. It represents a substantial part of the capital investment in a business—not only in the cost of the inventory items themselves, but also the cost of housing them, financing them, etc.

Inventory items that do not move are of great cost to a business. Items that turn quickly are a great boon to a business. Yet many of the pulsations as they take place in the inventory account are unknown to management until they are too late for use. Automation is able to assist materially in this area.

For example, consider a client in the retail business with approximately 30,000 different items in its stock. We have converted their inventory control system from a manually posted card system to automation. Here is what we now provide to this client.

Each week we list, on a cyclical basis, by department, every item of stock in inventory—and its location. The client has numerous locations.

From "inventory outs," we can tell the client the "hot" items of merchandise that are selling. Since the date is shown for each inventory purchase, he knows the items that have not moved in 30 days, 60 days, 90 days.

On the basis of this information he is able to plan periodic sales of slow-moving stock.

The client receives an inventory summary showing inventory at the beginning, purchases to date, sales at retail, sales at cost, gross profit on each item of sale, gross profit by category, open-to-buy quantities, and, by annualizing the cost of goods sold, the rate of inventory turn on each item of merchandise is computed.

When the buyers go to market, the information by factory and also by description of item is available to them.

Automation again gets the vital information up on the table where it can do the most good—and at a time when it is not merely historical in nature but when it can be used for management planning.

Membership billing. Club membership billing can be simplified by using a computer. If a club member of a golf club, for example, is billed a constant amount monthly, based on his spending membership classification, it is merely necessary for us to identify the member with his class and the machine will do the rest.

If the house charges for the member are recorded on tape, or cards used as restaurant and bar checks, we then may have automatic billing of both the dues and the house charges.

If the computer is instructed to calculate in a separate column the charges for the current month for each member and his year-to-date total, it will automatically compute a sales analysis by member and by class of member.

If the machine is instructed to divide the cumulative figure to date for the year by the number of months a member has been active during the current year (so as to differentiate new members who have joined since the beginning of the current year from the members of longer standing), we have a confidential list of the average amount spent per member per month.

Management then knows, currently, the relative value of the different classes of members, including the amount of the dues revenue and the amount of the restaurant and bar revenue. Changes in dues structure may be suggested according to results obtained.

If the machine were instructed to list the members in graduated order according to the amount of money spent per month, we then would know the range of the figures, the median, whether or not minimums should be set, how many members would be affected by the proposed minimum, and whether or not it would affect too large a portion of the club membership.

By analyzing the amounts spent by the individual members, who in most cases are known to the management of the club, an additional storehouse of information is brought to bear on the figures. For example, member A may have been ill and therefore may have spent little money during the period under review; member B may have been out of town during the period. Or vice-versa, members who have been active in the club may not be supporting the house activities: reasons can then be determined and corrected.

All of the above information could be sought out under conventional methods of accounting, but automation provides these components as the norm, or as by-products, at negligible cost to the management. The fact that the information exists is not nearly so important as whether or not it is utilized in the day-to-day operations of the club.

Buying decisions. One manufacturer of computer hardware recently conducted an experiment for a CPA's client, who is a wholesale distributor, to determine whether a computerized system could be designed to provide for automatic "buying."

At the time this was considered a difficult computer application, since many buyers feel that purchasing is based upon a sixth sense which only they possess, and that the reasoning used in determining a proper purchase could not be defined. Nevertheless, the experiment was started.

The buyers were first asked which basic data they considered in determining a proper purchase. Based upon their answers, the relevant data were programed into the machines. The machines then came up with their first tentative purchase order.

The buyers disagreed with some of the purchases. The reason for the difference was pursued, and the machine was then instructed to consider these additional factors in determining future purchase orders. This process continued until the machine finally came up with results, still different from the buyers, but which the buyers, upon reflection, admitted were probably more prudent purchases than theirs.

Do not forget, the machine was using the buyers' judgment—not its own. The machine was merely applying to a problem everything that the buyers said was important in solving that problem.

But, unlike humans, once a machine is programed to apply certain considerations to a set of data, all these instructions will be applied to all future problems without exception. The machines will not forget any one of these considerations and as more experience is gained and more factors added, the answers will become even more reliable.

Furthermore, these instructions are applied to problems at a rate of thousands per minute.

Cash flow. Just recently, my office worked on a cash projection for each month of an ensuing year. We did this cash projection by the familiar long method. On the first schedule, in addition to the opening cash balance, we anticipated the predictable receipts, other than operating income, and the reasonably anticipated disbursements, other than operating expenses.

On another schedule we listed items of income in varying amounts from 90 per cent down to 30 per cent. Correlated with that, we listed variable expenses that fluctuated between the 90 per cent and 30 per cent. From this format we were able to show the cash surplus or deficit which would be created each month, depending upon whether or not the revenue was 90 per cent, 80 per cent, 70 per cent, and so on down to 30 per cent.

The cumulative cash balances at the end of each month were also shown. The preparation of these schedules was a long, arduous process. Also, we realized that if one of these figures were changed at any time subsequent to the preparation of the statements, the whole report would become obsolete.

After this report was prepared, we programed the same basic data into the computer so as to duplicate the original long method report.

There are different work potentials in the two reports, however: First, in the computer report all headings were stored in the computer's memory so that for all time in the future these same headings will appear; therefore, the reprinting of this particular report would be automatic at 600 lines per minute.

Second, under the computer system, if any of the receipts or disbursements were changed, or any item of revenue or expenses changed, by merely inserting the changed figures for each month of the year we could completely update the report in a matter of three to four minutes.

But, far more important, we are able to show the various financial results that might obtain at the various levels of sales, with full consideration given to the costs and expenses that correlate with those various levels.

By showing the range of the information and calling management's attention to the critical point of operations, management can then devote its full attention to avoiding that critical level. Or if a proper level of sales cannot be maintained, expenses may be cut at the appropriate time. The cloth can be cut to fit the pattern!

Estate planning. In estate planning the computer is a valuable instrument in dealing with thousands of facts that ordinarily tie up a considerable amount of an adviser's time. A great deal of information relative to a client's estate can be punched and placed in computers.

In one estate planning operation known to the author, 80,000 instructions guide the computer in relating such information as assets held; property owned individually, in joint tenancy, or in tenancy by entirety; number of testator's children, and their ages; marital status; etc.

This particular program stores 15,000 footnotes or references based upon results obtained after applying 80,000 instructions to data. And if one of the footnotes or instructions needs to be changed, it is a simple matter to add the change into the program. For example, if a person's estate is of a certain size and he has not taken advantage of the lifetime exemptions concerning gifts, there may be a footnote to consult with his attorney. There also may be a footnote to consider changing title to his residence.

An adviser might think of every significant factor of a client's case except that contained in instruction No. 72;004—the computer will not forget it. The adviser may customarily think of footnote No. 9,628, but forget to apply it in a particular case; the computer will always remember it. Thus the estate planning program will continually be refined, and will retain all refinements forever.

The machine does not have judgment, but it does catalogue and apply all considerations that we are able to define in forming our judgments. It certainly narrows the judgment area. And if a new idea or a new instruction must be added to the program in the distant future, that too will be automatically applied to all future problems.

Historical statements. Many CPAs in public accounting practice today know that as their firms grow, it becomes more and more difficult to maintain close contact with clients. It is possible, however, to stay close to a client's figures.

Today, automation makes it possible to record all the significant items of the balance sheet and income and expense statement of clients in a format that compares his figures for the past four years.

For clients without automation equipment, balance sheet and income and expense items may be recorded according to codes established in the computer program.

Balance sheet items in the finished report may be shown to the right of the money columns, and the percentage of each component of the total assets. For example, cash may be 5.2 cents of each dollar, accounts receivable 13.4 cents, and so forth—these figures are shown next to comparable items of prior years. This also applies to liabilities.

The percentage that each item of cost is to the sales figure may be shown in the income statement—and again next to figures of the prior three years.

In planning the job program, CPAs can decide which information is important to us and to management, so that this information will be called to our attention currently with each new report. This information includes current working capital comparisons, net ratios, cost comparisons relative to sales, inventory turns, number of days' sales in accounts receivable, and other relationships that might be suggested.

Once these ratios and relationships are defined they may be programed so that the machines will automatically compute and update the reports with every new set of figures—prepared at calculation speeds and print-out speeds of hundreds per minute.

Once an accumulation of back data is stored in the machine, this information may be used in numerous calculations and comparisons at no extra cost to the management.

And these back figures often bring to bear on a problem valuable information which, because of age, would have been completely disregarded in the consideration of the problem. They add a new dimension to the study of trends, ratios, and comparisons and thereby make more scientific our interpretation and diagnosis of the financial story.

Family costing: cause/effect relationships. As automation develops, it's quite probable a completely new type of report will evolve that will be used quite extensively in future financial reporting. This will be a report that shows not only dollar amounts, but cause and effect relationships that also exist in a business. A simple example of the nature and importance of this type of report will clarify this point further.

Assume in the construction business that costs of a number of 3½-ton tractors are compared: Equipment A spent $1,200 for gasoline during the current year, equipment B spent $850. Naturally, in comparing the two, the question arises: "So what, how many miles did equipment A travel and how many miles did equipment B travel?" The wages for the operator chargeable to equipment A might have been $2,000; equipment B, $2,200. Again, "So what, how many hours did the operators work on the respective pieces of equipment?" The same question may be asked for each expense chargeable to the individual pieces of equipment.

For a construction company we have designed a format that brings these cause and effect relationships into focus.

The usual conventional dollar amounts of the transactions are at the top of the report. At the bottom are shown the miles traveled, the number of gallons of gasoline consumed, the miles per gallon, the operator hours. By dividing hours worked into the cost of wages, the cost per hour for the operator can be computed. The total cost of operating the equipment can be divided by days worked, by miles, or by hours—by whatever divisors seem significant. We can show the number of units delivered by each piece of equipment. The machine computes these costs per unit for each piece of equipment at speeds of hundreds a minute.

All of the above information is of extreme interest to this particular company—but still, it is not the full story. Next, they would like to be able to compare how one 3½-ton tractor compares with another, not only in total costs but for all of the component relationships as well.

We therefore inform the machine that equipment No. 102 is a 3½-ton tractor, No. 105 is a 3½-ton tractor, No. 182 is a 5-ton tractor, No. 240 is a 3,000-gallon trailer. We identify the family to which each numbered piece of equipment belongs. We now run a report which shows in the total column all the dollar amounts and also the cause and effect relationships for the total family of equipment, and, as a spread, these same component figures for each piece of equipment within the family.

This report shows very clearly the inefficient equipment and also the cause of the inefficiency: The piece that may be inefficient from the point of view of gasoline economy may be efficient from the point of view of cost per productive unit because of its larger productive capacity. This report permits a comparison of likes with likes.

And the report can also be expanded. In the construction business one piece of equipment may have a complete overhaul at the end of the second year of operation; another piece may have an overhaul at the start of its third year of operation. One year's figures are not adequate in arriving at comparable costs of operating equipment. Our firm has therefore tried to get away from period accounting for one year and to show for each piece of equipment the costs and components described above which are applicable for the three preceding years, in addition to those of the current year. This furnishes management with valuable information.

We can now divide overhaul costs by miles and come up with a significant figure. This figure might not have been accurate had it been done for one year alone. But now labor dollars can be divided by numbers of hours and productive units to get unit costs, costs which might have been distorted in one particular period. We can see the ranges of costs—the high figure, low figure, average figure—and this is done not only per piece of equipment but also according to family and according to location of the respective units. This report assists management in formulating its equipment replacement policy. While depreciation costs go down as the equipment gets older, operating costs in all probability go up. Immediately evident are the miles per gallon per piece of equipment relative to its age. The Fords may be compared with the Dodges, with the Macks; truck costs can be compared according to their efficiency while under control of different operators. Their retrieval information possibilities are almost infinite.

Now that we have this information on hand, all the cost data necessary are available to store standard costs in the machine's memory.

Hourly labor cost per operator, per helper, are known and, where applicable, according to geographical area.

We know the direct cost of operating the different pieces of equipment.

We decide which is the significant factor in cost calculations—the mileage figure, hours worked by the equipment or days on the job—and use any one of them. Only cost components that are pertinent are stored in the computer.

If at the end of a day an operator reports that he worked five hours, and the equipment traveled 140 miles and worked for five hours, the machine will seek out the cost per hour for the operator according to his location and multiply out the labor cost. It will seek out the family to which the piece of equipment belongs and its location, multiply the hours worked by the cost per hour or by the miles traveled, whichever figure is deemed appropriate. If material were used on the job, by merely reporting the type material and the quantity, the machine will seek out the cost of the material and compute its cost.

In addition to the above direct costs, the computer's memory may store the burden that applies to the different direct costs and compute the total cost of the job and the resulting profit or loss.

If the income is reported daily on this basis, it is possible to come up with complete income and expense statements daily, per piece of equipment and per contract, with little difficulty.

If the coding system is designed to separate the costs according to the breakeven concept of accounting, it prepares breakeven results automatically. Once cost factors are stored in the computer and identified, the machine will make all the necessary calculations upon introduction of the variable information.

"Explosion report." This report is one in which we record financial data in one particular way, prove it to a known total, and then explode out results in completely different arrangements of the figures. For example, in connection with banking we have an expense report in which the items that are to be apportioned are listed in varying percentages.

The methods of apportionment have been predetermined and have been written into the computer program. Let us say that the amount of the expense is $2,452. This same figure totaling $2,452 is exploded out by branch, and immediately following that we explode out the same $2,452 by Federal functions. Thus we have the original transaction according to the general ledger code of the particular bank, according to branch accounting, and according to Federal function.

This is very useful in other types of industry as well. For example, consider the item of labor costs: This expense can be classified according to seasonal, fixed, casual labor, etc., and then this same total may be exploded out in many different cost relationships.

How does this work with regard to sales analysis? Take a company in the plant-mix business. We list various products sold during a specified period by ton and dollar amount. Each one of these products has a different formula and a different mix of ingredients. After listing the sales analysis by finished product, the ingredients that went into that particular product according to the standard bill of material that makes up the end product are exploded out. In this way it is possible to control costs of the ingredients at the source.

Annualization of statements. In a seasonal business it is often normal to have losses occur in the off-season. Whether or not these losses are of significant concern to the management depends upon their comparison with prior years. These losses may be greater than the norm or they may be less than the norm. The loss alone is not sufficient to judge how well the company is doing during the current year.

Many of these companies find it necessary to combine the actual operating results for a part of the year with estimates for the remainder of the year based upon prior years' figures.

One method by which this type of statement may be prepared on a routine basis with automatic data processing equipment is to present statements for a five-month operating period ended, say, on May 31 on a normal basis. The income and expense statement would start with sales, then show the components of expenses, and finally the profit or loss for the period ended May 31.

From the prior year it would be relatively easy to take May 31 results for that year and subtract that figure from the December 31 figures in order to get a basis for estimating the period from May 31 to December 31.

This deduction of May figures from December 31 figures could be performed merely by placing in the machine the figures of the previous year for May 31 and the figures for December 31 and programing the machine to subtract one figure from the other.

To continue, if labor costs were up 5 per cent for the current period as compared to the preceding year, the labor cost representing the period from May 31 to December 31 could be multiplied by 1.05 within the machine.

If material costs were up 12 per cent, the material costs as developed for the remaining period could be multiplied by 1.12 with little effort.

If administrative salaries were up $3,000 per month, this increase in dollar amount could be programed into the machine with little difficulty.

This same principle could be applied to the income account taking into account product mix. One particular product might be selling for 6 per cent more than during the previous year; one could be selling for 3 per cent under the average selling price for the preceding year.

By computing as a base the remainder of the preceding year, and applying to it the new conversion ratios for each one of these figures, it may be seen readily that information could be converted each month from the remaining period of the preceding year or years to a revised estimate for the current year.

At the end of the six-month period this same principle could be applied; that is, the six-month actual report plus a six-month converted estimate for the year.

After seven months it could be seven months actual plus five months remaining, converted on the basis of the new ratios within each one of the accounts. In other words, we would be telescoping in on the annual figures and removing the surprises from the company's figures—which is one of the objectives of financial planning.

The annualization of statements could be produced by the machine with little effort and become as routine as the normal monthly trial balance. If it were desired to take the last three years as a base, compute an average and apply a percentage to that average, that could also be done within the machine's programing. If you can do it in your head, the machine will do it merely by carrying out your instructions according to the sequence of calculations you would use in performing this task by the long method.

The above cases indicate that they have a consistent theme throughout. In each of them the computer has been used as a means to make possible the marriage of two professional talents: management advisory services and financial recording techniques.

We have not been looking primarily at examples of the ability of the computer to process mass quantities of data at rapid speeds; we have been seeing it combine the accountants' skills in management services with his skills in financial recording.

At this point many will be wondering how this marvelous—and fairly expensive—tool will fit in the economic framework of a customary accounting practice.

Naturally, it is very difficult to generalize in this area because of the various degrees to which a CPA may become involved in the computer business. He may rent or own his own equipment; he may work through the service bureaus or through the banks; he may combine with other

CPAs in a pooled operation; or he may join with other CPAs in a membership-type program.

The costs incurred in computer practice, therefore, will depend on which mode of operation an individual chooses. The important point is that one or more of these modes is within the economic range of every CPA firm.

Even though it is difficult to put a figure on the economics of computer practice without knowing specifics, there is one basic point that I would like to stress: This concerns the income potential that exists in this practice. The increased depth of the services performed in a computer practice means a higher base amount of fees.

It is not unusual that sophisticated computer work for one client will total fees of $2,000 to $3,000 per month. These fees naturally must be justified in the opinion of the client's management or, as we all know, they never would be accepted.

When management does the work in their own offices, their costs run at least as large as our fees and most times larger—for computer services—and they do not get all the collateral benefits that are by-products of a CPA's computer service.

In my office we use a rule of thumb that we can do the work for the client at a cost no greater than that currently incurred by him. And for the same cost he gets infinitely more significant information than he could from a noncomputerized system.

Accountants should be extremely active in the development of computer systems. We owe it to our clients, ourselves, and our staffs. We are completely familiar with accounting proofs and accounting controls, with methods and systems, with business reporting, with costs, breakeven figures, pro formas. We have become more or less the business doctors—we are eminently qualified to be the main participants in this field. But are we assuming our full and proper role in its development? How many of us are computer oriented? How many of us are really aware of the great potential offered to us?

Accountants must decide today: Who are the leaders going to be in the development of this new field—who will the prime movers be?

Will it be the engineers, who certainly are qualified in scientific methods?

Will it be the mathematicians and physicists, who are extremely sophisticated in the use of computers? They have done the programing for the missile age—their work in operations research has important business applications.

Will it be the bankers? They have the money, they have the hardware.

In addition, they have a captive audience. They have been making great strides of late with the business public.

Or shall we be able to retain our present position of prominence in the business advisory areas—and if so, how? It has to be more than self-preservation—it must be based upon good solid business reasons.

And what should we, as practitioners, be doing about it today? How do we participate meaningfully in this new field?

First, we must improve our own skills. This may be accomplished through educational courses designed to train us in scientific techniques of solving problems. We must study causal relationships in business, and learn what operations research is all about when applied to business problems. We must further our studies in the management sciences. By broadening our base, we will know what additional information we want to retrieve from computer systems.

The American Institute has already taken an active role in the indoctrination of the regular practitioner in this new computer field. Professional development courses will be presented in computer science. These courses need not at first be at a highly sophisticated level—that can come later. By this I do not mean the mechanics of programing: In my opinion, programing is a technique for the specialist, not necessarily for the general practitioner.

But the professional CPAs must gain overall control and direction of some equipment. They must band together to share the resources of the computer. With improved communication providing for direct input to machines it will be no problem for CPA firms in widely separated locations to utilize centralized computer facilities.

There must be a complete interchange of ideas by accountants among themselves as they develop computer concepts and methods. This kind of exchange is vital to the future of any profession.

RICHARD K. PUDER, CPA

Computer Service for Clients

THE COMPUTERS available on the market today are vastly different from the first models introduced ten years ago and technological advances continue to be made at a rapid pace. There have been significant improvements in reliability; operating speed of processing, input and output units; flexibility in use; capacity of memory storage; miniaturization; and requirements for site preparation (i.e., power, temperature, humidity, etc.). Major breakthroughs have also been made in programing techniques, random access and random processing, automatic data transmission to the computer from remote source locations, and automatic conversion of data into punched paper tape or punched cards, which can eliminate manual key punching almost entirely. These and innumerable other technological improvements have brought the computer within reach of small business as well as large, by making possible increased efficiency and ease of operation, and much lower costs than in the past.

Although the purchase price of the smallest digital computer today still greatly exceeds that of a bookkeeping machine, its practical application and justification is no longer limited to the giant corporations. Even when the cost of full-time use of a computer cannot be justified, manufacturers' and independent data processing centers and other sources permitting the part-time use of a computer are now quite common. Thus, today the benefits to be derived from a digital computer are available not solely to big business but to medium-sized and even small business as well.

The businessman is facing greater complexities in operation and increased paperwork, requiring a larger volume of data to be digested than ever before. Competition has become keener and profit margins slimmer. Mistakes due to "seat-of-pants guestimates" resulting from incomplete information have become more costly. Thus, today, clients of the local practitioner, small as well as large, have a growing need for the advantages of a computer.

The need to increase management efficiency and effectiveness is being met most often through computer applications that provide: (a) information that is more accurate and more up-to-date than data gathered by conventional methods; (b) increased executive time for decision making through elimination of much of the detail and clerical work now required of management; (c) management-by-exception techniques; and (d) key management information never before practical to obtain. This management information is required by the small businessman as well as the large; both are looking in greater numbers to the computer as the tool to solve many of their business problems.

The applications of most CPAs' clients fall into two broad categories: (1) periodic financial management reporting and (2) solution of nonrecurring data processing problems. The first encompasses the preparation of sales analyses, gross profit and net profit analyses by line, product, division, etc., inventory control, production control, job cost analyses, budgeting, and so forth. The other application includes business forecasting; various one-shot runs, such as inventory analysis, including extensions and summarization; and simulation studies which project the resulting effect on a business of contemplated management decisions. Computers may also be used for management training through business games, of which there are many types. All are basically designed to teach executives the interrelation of decision making on all phases of a business and condense years of practical experience in a "dry-run" experience taking days or only hours.

It is reasonable to assume that the clients of the local practitioner will look to him for advice and service with respect to this relatively new field, providing the local practitioner is sufficiently knowledgeable. Usually the client has little or no knowledge in this area and has difficulty in knowing where to turn. Most small independent data centers essentially process only according to detailed instructions. It is normally prohibitive in cost for the smaller client to hire systems experts or to train existing personnel to be experts. The accountant, on the other hand, already has knowledge of the client company, including top management, its major business problems, personnel, existing systems, and other invaluable background information. Furthermore, the CPA enjoys a confidential relationship with the client which plays a significant role in dealing with problems lying at the heart of his business.

Assuming that many of the local practitioner's clients have data processing problems that might well be solved through a computer application, and that these clients might well turn to their accounting firm to accomplish this, let us next review the areas that would probably be involved.

The first step involves conferences with top management to determine what is required. Usually the client must be informed as to what can be obtained. Particular emphasis should be given to the management-by-exception approach whereby he will receive, in lieu of voluminous listings and summaries, reports setting forth only the problems or exceptions requiring management action. The final determination of what should be obtained is frequently quite different from what the client originally thought he desired. When objectives have been determined, specific output requirements are then reduced to writing.

There then follows a detailed systems study. This encompasses an analysis of the present system from the general flow of paperwork down to the analysis of every exception from the routine; it includes every facet of record-keeping relating to the problem. The end result of this systems survey will be to reduce to writing the complete input requirements of the computer operation.

Once the input and output requirements of the computer operation have been established, it is then necessary to determine the nature of the computer operation, both as to the type of computer and whether or not it will be used full-time. There is no one computer best suited for all jobs; it is necessary to match the computer to the application. Determining which computer is best for a given application requires extensive familiarity with the field together with a high degree of judgment. If the client is large enough and the application substantial enough to justify the cost of full-time utilization of a computer, then normally it is desirable for the client to rent or purchase the computer. In this case, the accountant would probably be an adviser to the client's personnel rather than render the desired services himself, but nonetheless he would likely become the key man in the management team responsible for the conversion to the computer.

The majority of the local practitioner's clients, on the other hand, might be unable at the present time to justify the full-time cost of a computer. Even if the larger client could support the cost of a computer full-time, there might be factors suggesting the use of a computer located off the premises on a part-time basis.

Often the large client desires to convert certain applications prior to the installation of a fully integrated system. Buying a computer would be needlessly expensive until he is ready to put the complete system into operation. Then again, the client may wish to avoid the personnel and administrative problems of a new computer department or the business may be so seasonal that there will be considerable idle time at many periods through the year so that savings could be obtained through part-time use of another's computer. Although there are many other factors suggesting part-time use of another organization's computer—availability of back-up equipment, availability of personnel to work around the clock when necessary, and so forth—there is one further important consideration worth mentioning. In some situations, even though the cost of a smaller computer can be justified on a full-time basis, the part-time use of a large computer may offer the company more flexibility and efficiency and permit far better service and problem solution at lower cost.

All these factors emphasize the need for sound advice on what computer to use, and whether it should be used on a full-time or part-time basis.

If the decision is for a part-time operation off premises, which is likely for most of the local practitioners' clients under present conditions, there are several sources available. Service centers with punched card tabulating equipment have been in existence for some time; most populous areas have many from which to choose. Many of these have already installed computers, and several service centers have started up with computers only. In addition to the service centers, there are the so-called "data centers" or "data processing centers." These are centers established by the computer manufacturers themselves to make possible the rental of computers and peripheral equipment and the hiring of staff operators, programers, systems engineers and other related personnel, all on an hourly basis. A further part-time source is the rental of excess computer time from another user; such machine time is becoming more readily available as additional computers come into use. Still another approach is for a group of companies with mutual problems to pool their interests for a joint computer operation. Another new factor in the field is the college or university. There are many in the country with computers for educational and research purposes. Several of them look to commercial companies to help defray their cost by renting machine time in a manner similar to a service center type of operation.

The newest entrant into the field is the accountant himself. Some accountants are operating a computer within their own offices as an integral part of their accounting practices. (See articles 3 and 4, this chapter.)

Returning to the service to be rendered, after the input and output requirements have been determined, as well as the computer operation, both as to machine type and method of use, it is important at this point that a qualified top executive of the client be made responsible for the system. The systems and procedures that must be established for the computer application will require a very high degree of discipline and supervision. Therefore, this appointed individual, frequently an officer, must become familiar with the entire operation. He should be guided by the accountant as to the training and education needed to execute this key function.

The next phase of service is the determination of the modifications or redesign of the existing system required for the computer operation, recommendations for equipment and personnel changes, creation of proper systems controls and proper coding of all information. A manual of operations is prepared, spelling out each function and each operation under the new system.

After the new system and procedures have been determined, the computer programing may proceed. This programing is based upon the input and output requirements and may proceed once they have been determined. The detailed flow charts for the computer are first prepared, with particular emphasis on adequate audit trails and controls. These are then coded into machine language and the resulting programs are then "debugged." Debugging is the process whereby the newly created programs are tried on the computer and modified until they perform as intended. These finished programs are finally tested against sample data with known answers to determine that the computer results are proper.

The next phase concerns the conversion to the new system and implementation of procedures. Master files, history data, and opening balances are converted. Office personnel are trained and the manual of operations implemented. After the conversion, supervision is required of the office system and procedures and the operation of the computer to ensure integration of all functions and the working out of all problems not anticipated.

The final phase commences with the production of reports from the computer. All the reports are analyzed, interpreted and reviewed with management, not merely on an initial basis, but as a continuing service. Such reviews also cover improvement, updating and revision of the reports; expansion or reduction of their scope; and the management advisory services related thereto. It is this phase of the accountant's service, the culmination of all the other steps described, that requires the highest degree of judgment and skill on his part and is undoubtedly the most important to the client.

It is clear that those local practitioners who become sufficiently expert to render services of this type are extending their services to solve the key problems of their clients. In so doing, they have developed new work which is significantly productive and have taken one further step to ensure a close and valuable relationship with their clients. Their ability to provide such extended service places them in a leadership position within the profession and enhances their effectiveness with the client.

As to the operation of the computer by the accounting firm itself, there are no more than a handful of firms pioneering in this field, with many more watching and waiting to see how the field develops. A few have already abandoned their projects; others have satisfactorily persevered.

Before outlining the advantages and disadvantages of such an operation, it is the opinion of the writer that the operation of a computer, if properly and soundly approached, can be established within an accounting firm with complete propriety. Based upon careful and thorough study of the ethical problems involved, it is the writer's conclusion that the Code of Professional Ethics can be fully complied with. This has been affirmatively supported by private written opinions received from the American Institute of Certified Public Accountants, and many of the major points are further amplified by the opinions expressed by John L. Carey, executive director of the AICPA, in his book *Professional Ethics of Certified Public Accountants.*

Cons of computer operation

First, let me discuss the disadvantages of an accounting firm operating its own computer as a service to meet the data processing problems of its clients.

One argument often advanced is that the responsibility is too great. With all of the problems facing the accountant, why must he expose himself to the actual processing of the client's data, where an error in input data made by the client's personnel, over which he has no direct control, can result in an incorrect report? Such inaccuracies could conceivably lead to bad management decisions, which might place all services rendered to the client in jeopardy. Therefore, those that fear the inability to control and to protect against errors argue that it is sufficient to render the advisory services and to let someone else have the operational headaches. Furthermore, the establishment of a computer operation demands the full-time efforts of a partner for a long period of time.

Not only are the necessary qualifications of such a partner difficult to come by, but also it is difficult to take him away from his productive work for the creation of this new department.

Then those who argue against the computer operation as part of the accounting firm state that this is really a separate business that ought to be run independently of the accounting firm, inasmuch as the operating phase requires skills of the businessman rather than those of the professional man. They agree that the phases other than the actual operation of the computer are clearly an integral part of the accountant's services, but point out that the operating phase represents a mechanical (or electronic) operation rather than a professional service.

They also challenge the adequacy of the profit potential with the following points:

The payout period is too far in the future and too speculative, with possible losses in the first years. There is an inordinately high initial investment to establish the operation on a paying basis. Then, looking to the future, they see competition entering the field to such an extent that profit margins will be reduced to an undesirable level. They see this competition augmented by the computer manufacturers entering this field on a small profit, no profit, or even loss basis, in order to gain a better position for the ultimate sale of their product.

Another point raised is that the accountant, in operating a single computer, is attempting to match one computer to all his clients' applications. There are several reasons why they believe this to be unsatisfactory. The main reason is that, even though technological progress has brought to the market many computers, each of which might handle a major portion of the clients' applications, there would still remain many applications not efficiently met by whatever particular computer the accountant might install. Another reason is that the accountant ought to deal on equal terms with all computer manufacturers. This, they say, cannot occur where the accountant operates one computer since he unconsciously becomes associated with, and a proponent of, that particular manufacturer regardless of any effort he may make to the contrary. Lastly, they reason that the accountant, in situations where some computer other than his own might be most efficient, might not be objective enough, particularly in the initial stages of establishing his operation when he is confronted with high costs and idle time on his computer.

Finally, the argument turns to personnel. Because of the explosive growth that has taken place, and will continue for some time, and the highly skilled educational and experience prerequisites for programers and operators, competent personnel are and will remain scarce. Their high-level salary structure is not compatible with that of the accounting staff, presenting a delicate problem. All in all, the personnel problems may be even more serious in the computer area than the present-day staff problems already facing the accountant.

Pros of computer operation

Let us turn to the advantages in rendering computer service within the accounting firm. First, there is a responsibility to establish, control, integrate, and implement the system. Rather than relying on third parties to operate the computer, the CPA will find that the surest and most effective way is to do it himself. Besides the obvious control features, this ensures a professional level of performance which unfortunately is too often apt to be lacking with data processing centers and other alternatives. Most such alternatives rarely achieve the standards for personnel, judgment towards assignments, or reliability towards commitments that are desirable. Operating the computer within his own office gives the practitioner the ability to control these factors to his satisfaction. Yet there is much more to be gained. Even where the total service could be rendered capably without personal supervision of the computer operation, the practical knowledge obtained through the solving of operational problems develops an expertness which cannot otherwise be achieved and is invaluable in executing the other phases of the service.

In the many conversations with clients concerning the part-time use of a computer, the problem raised most frequently was the concern over confidential records being placed with an outsider. The transmission of data by punched paper tape rather than original documents does help to allay these fears, but nonetheless reports and other information vital to the life blood of their business are now passing through the hands of a third party in a service center operation. Such a third party may be doing work for a key competitor, thereby exposing the client to disastrous results if the data were to get into the wrong hands. Since the accountant has already established a confidential relationship with his clients, there is little if any concern on this score if the accountant operates the computer rather than the third party.

A computer operation established within the accounting firm has a long-range profit potential which is difficult to measure. The projections of breakeven points will obviously vary, depending on the manner in which the accounting firm intends to enter the field. Once in the black, the profit potential is substantial, naturally varying with the ability of the accounting firm. With the improvements in data transmission which are now just over the horizon, the feasibility of operating a centralized computer in an accountant's office for many clients is increasing, which directly enhances the profit potential.

The indirect advantages are perhaps equally important. The public image of the accounting firm is greatly strengthened by the computer operation. This image is created solely by word of mouth; there is no implication that it is to be advertised or promoted in an unethical manner. Nevertheless, the impact is considerable for the local practitioner. Another indirect outcome is the increase in all services through new clients, new contacts, etc., made possible by performance in this new area. It definitely complements services now rendered. Lastly, it soundly establishes the firm as expert in management advisory services. These indirect values cannot be empirically measured, yet there are those who have gone so far as to state that, even if the computer operation does no better than break even, there still is sufficient justification for its continuation.

Thus it is seen that there exist strong points of view, both pro and con, as to the feasibility of an accounting firm operating its own computer. For those firms with foresight and long-range vision that are willing to undertake the initial cost and assume the additional responsibility, the installation of a computer can establish them as leaders in this "Electronic Revolution," and will permit them to be all the more effective in the solution of the data processing problems of their clients. However, those who feel that installing their own computer would create too many problems and headaches, necessitating tremendous effort with inadequate profit potential, would better expend the effort required along more conventional lines.

In conclusion, let me trace the thoughts I have developed. Many of the clients of the local practitioner already have serious data processing problems which can best be solved through a computer application. Whereas these applications, in many cases, were neither feasible nor practical a few years ago, they are both economical and desirable now because of the technological changes that have improved computers. Within the next ten years the number of clients requiring computer applications will increase tremendously. The services which the local practitioner renders to his client can be greatly increased through entry into the computer field. Whether or not he operates his own computer, these services are very productive to the accountant and are of value to his clients.

JOHN E. LENNOX, CPA

Low-Cost Computers Help Small Firm Grow

ELECTRONIC DATA PROCESSING has already made tremendous inroads in the business world, and, with the variety of small, relatively low-cost computers that are available today, it is now easily within the reach of small businesses, including the CPA office. Furthermore, EDP has now reached the point where it influences the work of all CPAs whether they want it to or not. So it is essential that all of us in public accounting practice get to know as much about it as we possibly can.

There are many ways of learning about EDP. We feel that our firm has taken the most direct route possible—that of installing our own computer and setting up an accounting service bureau to process data for our regular clients, other CPA firms, and business firms seeking data processing services. This may not be the answer for every accounting firm, but so far it seems to have paid off for us.

Why automate? Lennox and Lennox is a small CPA firm on Staten Island in New York City. In 1960, we had a staff of three CPAs, ten staff accountants and three clerical employees. Like most firms, we wanted to grow. However, again as in the case of most small CPA firms, a high proportion of our service to clients was in the form of monthly audits, posting the clients' general ledgers from the various journals of original entry, making adjusting and accrual entries and taking off the financial statements.

Expansion of hand-written work requiring trained personnel poses certain economic problems. The work is highly labor-intensive and characterized by seasonal peak loads. To prepare financial reports rapidly enough to be useful to the client takes a lot of manpower, much of which may not be required in nonpeak periods.

Mechanization—whether by means of accounting machines or computers—seems to be an obvious solution. Yet this solution presents its own problems. You need a big enough work volume to justify the cost of the equipment and the systems men and programers that are required.

We felt that we could attain that volume. That confidence has proved well founded. Furthermore, in accordance with our expectations, our first-hand experience with EDP has given us an excellent foundation for providing our clients with systems advice and related management services.

Our primary objective in deciding to install a high-speed computer was to satisfy our clients' desire for more information in improved formats made available as quickly as possible. This objective has been attained. With our computer we can provide our clients with readily understandable reports, tailored to their individual needs and processed with greater speed and accuracy than ever before. The speed and capacity of the equipment gives us much greater flexibility in accumulating and assembling data for a wide variety of financial and subsidiary reports. Information can readily be condensed or exploded for quick analysis.

The computer has been equally beneficial for us. It has significantly enlarged the scope of our operations. Our gross volume has increased by 40 per cent, and much of this is in fields, such as EDP consulting, that were previously unfamiliar to us. At the same time our staff has increased by only 19 per cent; we still have three CPAs and ten staff accountants, but we now have two EDP programers and four clerical employees. We are so pleased with our EDP experience, in fact, that we now plan to install, in early 1965, a larger unit capable of handling greater work loads.

We were well aware, of course, that the installation of EDP equipment is a major undertaking. If there is no clear understanding of what functions the equipment is to perform, the results can be disastrous. So, while we were considering what sort of computer we wanted for ourselves, we began to acquire some experience in handling data for electronic processing by farming out some of our work to commercial computer centers.

We found the work done by these centers to be generally good but on the whole inadequate to meet our firm's needs. Commercial service bureaus are often run by nonaccountants, whose lack of knowledge of accounting terminology and accounting systems sometimes handicaps them in producing the results desired. Furthermore, the operations of commercial computer centers are programed to fit fixed formats or to produce standard reports designed by them; any deviation from their procedures results in greatly increased costs.

Needless to say, this finding greatly encouraged us in our decision to enter the field. It reinforced our conviction that there was a place for the CPA firm in service center work, a role that is not directly competitive with that of the commercial computer center.

We are convinced that more and more accounting firms will be offering computer services geared to the needs of the accounting profession and its clientele. Such firms, armed with the manpower and equipment required to process the most specialized accounting work assignment, can expect an abundance of work referrals from accounting firms that do not have their own electronic data processing equipment. Such, at least, has been our experience.

Pre-installation studies

Beginning in July, 1960, we spent many hours studying the why's and wherefore's of automation to make sure that our installation adhered to a definite pre-arranged pattern of goals and means of achieving them. The steps taken by our firm encompassed three essentials for insuring a successful systems program: machine appraisal, systems planning, and education.

We got in touch with the major computer manufacturers. My partners, Cyril J. Lennox and E. Keith Danischewski, and I spent many many months evaluating various EDP systems to determine which one would most closely meet our processing requirements. Such characteristics of the available computers as cost, capacity, speed and upkeep were considered in detail. We also had to resolve such questions as whether the equipment should be rented, leased or purchased and how significant a problem was created by the danger of obsolescence.

Because the equipment was to be used primarily for conventional accounting applications, our final choice was a medium-sized digital computer, the National 390. Early in 1962 we signed a lease-purchase agreement. The system was installed that July.

While we were deciding which computer and auxiliary equipment to install; we defined the desired results to be obtained from the computer. We agreed that the machine was to be installed *after* the procedures it would handle had been established. Only in this way, we felt, could the computer operations be expected to function smoothly from the outset. We were determined to avoid the fatal error of devising procedures to fit the equipment rather than selecting equipment that could execute the procedures we wanted.

We serve small to medium-sized companies with annual sales volumes ranging from $200,000 to $34 million and employing from forty-five to five thousand people. They include small manufacturers, retail stores, heavy construction contractors, freight forwarders, engineers and surveyors, insurance brokers, and suppliers of such building materials as ready-mix concrete. The majority of our clients are in the metropolitan New York area, New England, and Pennsylvania. But since many of them have branch offices, plants, or subsidiaries in other parts of the country, we actually process work for offices from coast to coast.

Our clients are as diverse in their information requirements as they are in their size and business. Thus, we realized that even though preparing typical end-of-the-month financial reports would continue to be the basis of our business, each client would need some degree of specialized attention. Furthermore, such additional services as cost and sales analysis, inventory control, budget comparisons, consolidated balance sheets, profit and loss statements, statements of application of funds, and various statistical analyses could be expected to play a greater role in our future.

A great deal of time, therefore, was devoted to systems planning to develop EDP procedures suitable for these and other accounting activities. Flow charts, methodically diagraming the various steps required to process material from source to computer, were developed, updated, evaluated, altered where necessary, and finally stabilized. This planning process was time-consuming, but the painstaking care that went into it was undoubtedly the most important factor in the success of our installation.

While the planning was under way, we entered the third phase of preparation—that of increasing our staff's general knowledge of automation. After all, the success of any EDP program rests on the manpower assigned to direct and operate it.

We encouraged our key staff members to spend as much time studying EDP as they could spare. Several of them—and I too—attended programing schools, where we received formal training in automation applications. For about a year after this training, when my regular duties did not interfere, I received additional technical assistance from the manufacturer in my own office.

Another valuable source of information on the relationships between automation and accounting was the New York State Society of CPAs, of which I have been a member for seventeen years. Many state societies, along with the American Institute of Certified Public Accountants, offer seminars and work-study programs that define problems in automation and explore their solutions. We have found these and other professional associations highly useful as vehicles for exchange of views on current practices, discussion of common experiences, and sharing of ideas on how best to avoid the pitfalls that sometimes mar the path of an EDP installation.

The manufacturers of computing equipment also are helpful as general sources of information. They report on a wide variety of EDP studies and installation case histories, and these results are usually made readily available without charge.

The equipment

The EDP system we installed has seven components: the central processor, two carriage-type accounting machines wired to paper tape recording punches, one reel-type paper tape photoelectric reader, one paper tape strip photoelectric reader, one carriage-type printer and input console, and one paper tape editor-splicer. Three full-time employees are required to operate this equipment. To process by manual methods and in an equal amount of time the volume of data the computer system now handles would require dozens of persons.

The central processor makes arithmetical computations and logical decisions in milliseconds. This means, for example, that it can calculate a company's Federal income tax liability (considering all the alternatives), place the accrued item in the liability section of the financial statement, charge surplus, deduct the tax, and report the net income —in less than one second. It can also calculate the gross regular pay, overtime pay, payroll tax deductions, and net pay of an employee— again within a second.

Data may be entered into the computer from four major sources: the console, magnetic ledger cards, punched paper tape, and punched cards. Our clients overwhelmingly prefer paper tape, because of its convenience and economy. Data entered can be stored by the machine, if desired, and retrieved in a matter of seconds. Processed or partially processed data can also be stored externally on magnetic ledger cards, paper tape, or punched cards. We therefore have complete flexibility in updating data from month to month.

The equipment also contains the usual mechanical features which provide duplicate computations and other accuracy checks. Its accuracy record has been splendid—of prime importance, obviously, in the success of the installation.

Upon completion of each processing cycle the data prepared by the system are bound in booklets and dispatched to clients. A covering letter accompanying each booklet explains the exact nature of the services performed. Each item of information is printed on translucent paper, which can be copied readily on any ammonia-process machine. Thus each master report is utilized both as a permanent record and as the source of as many duplicates as are required.

Services offered

Initially we used our EDP system only to process financial reports for our regular accounting clients. Within a few months, however, these clients began requesting additional services. The equipment proved capable of fulfilling the new tasks imposed upon it, and we soon were able to open our doors to service center assignments from a variety of businesses outside our own client list.

Our first such account was an engineering organization on Long Island whose CPA wanted us to process his client's job cost cards. Other outside accounts followed. These included both businesses needing some sort of data processing, usually referred by their own CPA firms, and other CPAs who wanted us to prepare financial statements and reports for them after they had reduced the data to punched paper tape.

By September, 1964, the total of outside clients had risen to thirty-nine. This, of course, was in addition to the seventy-seven regular accounting clients on the books as of the same month.

To meet the needs of these two types of clients, regular and outside, we offer two types of service, which we designate as entire and partial. The first, which is sought mostly by the regular accounting clients, is the processing of an entire assignment, typically a financial report, from input through output. The other, designed to accommodate the highly specialized needs of the outside businesses and the other CPAs, consists of processing only a portion of an assignment.

A typical partial processing job is one being performed regularly for a manufacturer of pillows and comforters. It is a system for anticipating inventory requirements of specific products so that the company can order mill goods from suppliers at the right time.

When "pre-billing" information is typed on tape-producing typewriters, data such as product code number and quantity ordered are captured on paper tape as a by-product. The tapes are then sent to Lennox and Lennox, where the material components associated with the product code number have been stored in computer-usable form. The material requirements are compared by the computer with the amount shown on order (in units) and exploded to indicate the various quantities of raw materials that must be obtained from the mills to fill the order.

All orders for the week are combined, and a breakdown in the form of a raw material requirements report is prepared for the manufacturer. He can then order the raw material for delivery in anticipation of sales requirements. Through this system the manufacturer avoids needless and costly overstocking of raw materials, while ensuring that all the basic raw material components have been ordered or are in stock before the production run is made.

A more complicated assignment was the job cost analysis prepared for the R. L. Eggert Company, a New Jersey manufacturer of refrigeration and retail food store equipment.

Whenever R. L. Eggert Company writes a contract, it assigns a number. All subsequent documents relating to the contract, such as price quotation requests and purchase orders, carry this identifying number. As the materials needed to fulfill the contract are received, the documents confirming receipt are collated by contract number. From these data, vendors' invoices are posted to accounts payable ledger cards.

As a corollary to the posting operation, paper tape is punched capturing the contract number, the date of the vendor's invoice, the vendor's invoice number, the type of material received from the vendor, and the amount of the invoice. Thus, in a single operation, three items are created: a hard-copy purchase journal, an individual accounts payable ledger card for each vendor, and a punched paper tape for later processing.

All this work is performed in the company's offices. Then the tape is sent to us. We enter the information it carries on magnetic ledger cards produced for each contract number. When the processing of the tape is completed, the cards contain, by contract number, such information as the costs of materials supplied, the amount of expenditure for direct labor, and the direct overhead.

The cards are updated continually until all the materials have been delivered and specific contracts have been completed. Then, on information supplied by the client concerning which contracts have been closed during the period, we prepare a listing of the status of all contracts. We tabulate the same information gathered on the job cost cards and list all the open contracts, thus calculating the client's work-in-process inventory at the close of the period. The client then has the information he needs to book the cost of sales on his records as well as on the work-in-process inventory.

When new entries are made during the life of the contract, we send the client a photo duplicate of the original job-in-progress ledger card. This card calls his attention to differences between the current and the estimated costs of fulfilling the contract. In this way, the client can tell exactly how much each contract he fulfills is costing him in terms of material, manpower, and overhead. Such up-to-the-minute servicing would be prohibitively costly with manual methods.

Input material

About 60 per cent of our clients prepare their own input material on standard accounting machine or business equipment in their own offices. Ordinarily they use adding or electric accounting machines wired to paper tape punches. After the client has tabulated the data, he sends the tape to us for processing. All tapes, of course, must fit the standard dimensions compatible with the computer, which reads five-channel tape. If the client has no tape-creating equipment of his own, we code and punch his written data for entry into the data processing cycle.

Most commonly, input information is mailed to our office. If the client is in a hurry, however, and if his office is nearby, we will pick up the material by station wagon, process it, and deliver the finished product—sometimes, if desired, within a single day.

The work that we do—apart from our new management services consulting—differs only in degree, not in kind, from the work that any accounting firm performs. We are still processing data for our clients; the only real difference is that we do it with a computer rather than with a pencil.

Thus, we have not found that our service bureau operations have posed any threat to our professional independence. As the American Institute and many of the state societies have already ruled, when a CPA firm performing data processing services for its own or other firms' clients follows the established rules of professional conduct, there can be no conflict. The use of mechanical equipment to expedite the gathering or presentation of data does not in itself have any effect on the CPA's independence.

Another possible problem that has failed to materialize is that of getting enough business to keep the equipment busy. Even though we are in a sense competing with commercial service bureaus which can advertise, we have had no trouble whatever in adding names to our list of clients.

Most are recruited by word of mouth or by referral from other CPAs who have used or observed our EDP installation in action. Some referrals have been made by EDP manufacturers. Thus, our system has proved to be self-generating; that is, the work it produces creates the demand for additional work. Our regular clients are continually asking for additional services, and most of our outside clients have come back with more work for us after completion of the initial assignment.

Our advertising campaign consists solely of the services we render, and our only public relations man is the computer. So far they have both done well by us.

Indeed, our only real problem has been that of scheduling work loads so that one processing operation does not interfere with another and so that each client's needs can be satisfied promptly. We have had to put a good deal of time and effort into scheduling, but so far our efforts have been successful.

Our system generally runs at full capacity about thirty-five hours a week. As in any operation there are slack periods—or downtime—during which the equipment is not in use. We utilize this idle time to develop and test new systems, follow preventive maintenance routines, make dry runs of new assignments, and review and refine current operations.

Sometimes we use downtime to prepare our own surveys of the various types of EDP equipment on the market. Often a company considering an installation for the first time is so deluged with advertisements and claims for this or that piece of machinery that its management becomes confused. We try to give them a complete analysis, based on our surveys, of the good and bad points of all the major systems. Then they can judge for themselves which, if any, of the systems they want—and why.

During other periods of downtime we work on specific new assignments to be programed into the computer or begin to analyze new work procedures. We also try to straighten out kinks in current operations.

Part of the downtime is devoted to reviewing the formats of the financial reports prepared by the computer and improving the paper and forms.

Tips for novices

Our EDP installation has attracted observers from as far away as France and Venezuela. It has been a real boon to our firm, both in improving the efficiency of our operations and as a source of additional business. We feel that it has been well worth the effort, but I must warn any accountant thinking of going into EDP that the effort involved is tremendous. Any knowledge you may already have of automation is an advantage since this knowledge, if lacking, must be acquired, but regardless of your background in management technology you will have to put a great deal of work into planning and systems design.

To those about to embark on a program like ours, I can offer the following specific suggestions:

1. Learn as much as you can about automation.
2. Get complete background information on all available systems before contracting for one. A system may work very well on some types of assignments but fall short in other areas.
3. Set realistic goals.
4. Program procedures thoroughly before beginning to operate the system.
5. Carefully consider the peripheral equipment as well as the computer itself. The two are complementary.
6. Don't expect too much too soon—and don't accept too many assignments at one time.
7. Expect to work, and work hard, and to encounter your share of disappointments; give up any thought of a 9 to 5 work day.

For the accountant who is willing to make the effort, the rewards of automation more than outweigh the difficulties. I am convinced that during the next few years a growing number of CPA firms will be setting up EDP service centers like ours. Automation can greatly aid our profession by giving it the opportunity to perform new services that would have been impossible only a few years ago.

Even those who do not want to acquire their own computers would do well to learn as much as they can about electronic data processing. In a short time the accountant who remains in the dark about automation may find himself unable to expand his practice or even to serve his present clients adequately.

ROBERT M. SMITH

Expansion of Service Center Operations — A Case History

WHEN A SALESCLERK in a retail store enters a transaction on a cash register, she is in effect doing more than providing the correct change and a receipt for a customer. She is also providing, on the internal cash register tape, a complete record of the transaction—what was sold, or at least the general classification of what was sold, the department that sold it, the price for which it was sold. A basic record has been created, the record on which all the important merchandising records of the store are based. The all-important data about the individual sale have been captured at the time the sale is made. Ideally, this data for each individual sale in each department can give the store information needed for sales reports, sales and inventory reports, sales analyses, even sales projections.

"Ideally" is the catch. For, unless the store has a computer, or access to one, the task of producing such records on a timely basis from hundreds or thousands of bits of information about individual sales is almost insuperable. An electronic data processor is a requirement if the best use is to be made of such information. Yet it is prohibitively expensive for all but giant stores in terms of hardware cost and the knowledge and experience required.

This situation is the background for the decision of the National Retail Merchants Association to offer centralized electronic data processing facilities to process machine-sensible data submitted by member stores and return hard copy reports to the stores.

But behind this simple statement of fact, there's a lot of time and hard work. There's also the story of a small, local CPA firm, Lennox and Lennox, of Staten Island, New York, which was finally picked as the data processing facility to handle the NRMA account over such corporate giants as IBM's Service Bureau, Litton Industries, and the National Cash Register Company.

Lennox and Lennox have been deeply involved in automation since 1960 and have had their own computer since July of 1962. The firm's principals, Cyril J. Lennox, John E. Lennox, and E. Keith Danischewski, had become convinced relatively early that a computer could solve that perennial problem of small accounting firms: handling a large volume of write-up work without building an unwieldly and expensive staff. As part of the preparation for installing their own computer, they began sending some of their routine work out to service centers. They quickly ran into difficulties because of lack of understanding of accounting terminology and techniques on the part of those who ran the centers.

Experience with commercial service centers only reinforced the accountants' twin beliefs that automation did offer great advantages in speeding the flow of detailed paperwork and that CPAs, if they had the proper equipment, preparation, and machine knowledge, could do a better job of mechanically preparing financial reports of all kinds than could nonaccountants.

Lennox and Lennox decided they were going to get that knowledge.

They approached the leading computer manufacturers to evaluate various types of EDP equipment, while simultaneously defining exactly what they wanted the equipment to do. The firm's three partners realized from the first that it is a fatal mistake in installing a system to order the computer first and then fit the procedures to the equipment. After careful analysis of their clientele, mostly small and medium-sized companies in the immediate area of Staten Island, and their present and projected future needs, Lennox and Lennox chose the National Cash Register Company's 390 as their digital computer. Detailed diagrams of all the steps necessary to process material, all the way from journals of original entry to hard copy financial statements, were perfected in terms of the 390, which was installed in July of 1962, under a lease-purchase agreement.

Meanwhile selected staff members had attended programing school, and others had studied EDP applications in other ways. New York State Society and American Institute of CPA meetings and seminars were visited, and literature from manufacturers was carefully reviewed.

It is to this careful and painstaking preparation for installation that John Lennox gives primary credit for the success achieved with the project almost from the beginning.

Trained as an engineer as well as a CPA, he probably had some advantages in adapting so quickly to computer techniques. Yet perhaps the main advantage was his early acceptance of the fact that the computer is here to stay and all accountants had better learn what it is and what can be done with it, even if they have no plans for computers of their own.

When the computer was first installed, it was used only to process financial reports for the firm's regular clients. However, as clients saw the speed with which their work could be done, they began requesting such additional services as cost and sales analyses, inventory control, budget comparisons, profit and loss statements, and other statistical analyses. All these assignments could be handled easily by the 390, so Lennox and Lennox found that they could take additional data processing work from new clients who saw the advantages of a service center run by CPAs. As word of the new installation spread, other CPAs also began sending data to be processed just as Lennox and Lennox had earlier sent tape-punched information to a commercial service center. By the end of 1964, the total of such outside clients, over and above the firm's regular clients, had risen to 39 companies and accountants.

Thus, for their original clients, Lennox and Lennox did the entire assignment from original creation of data through finished product. For the new clients, they did the final part of a job already partially completed by someone else.

Gradually, as the firm became more widely known, they began to accept consulting work on other EDP installations. Sometimes they would be called in by another CPA to evaluate work he had done, sometimes by the company itself. They added the first non-CPAs to their management for this consulting work.

All of this increased the firm's expenses, of course, but the increased business generated by the computer more than compensated for it. Gross volume increased by 40 per cent while the staff increase was only 19 per cent. By the end of 1964, the firm had the same three CPAs and ten staff accountants they had had for some time, but they had added two EDP programers and four clerks.

An idea of the basic costs of the venture: First of all, in order to get the 390 on a lease-purchase arrangement, Lennox and Lennox had to show a Dun & Bradstreet rating of a minimum net worth of $150,000. Expenses, purely for the computer installation and staff, after the machine was installed were as follows:

1. Monthly lease cost of the 390 and peripheral devices, $1,750
2. Purchase price of one input-tape-producing accounting machine for error correction and preparation of input data, $9,000
3. EDP personnel (two programer monitors)—annual salary, $18,-000
4. One clerk—annual salary, $5,000
5. Average monthly overhead, $750.

This was the situation as of 1964. But already the firm was working on their most ambitious project to date. One of their regular clients was Garber's, a small but highly efficient Staten Island department store. Garber's had for a long time been taking full advantage of Lennox and Lennox's computer capabilities. And Garber's was active in the Smaller Stores Division of the National Retail Merchants Association.

NRMA proposal

The NRMA, fully conscious of the advantages computers offered the large stores which could afford them, had evolved a plan: to develop a package program under which small stores could prepare their basic data in the form of machine-sensible records that could in turn be sent to a data center for further processing. NRMA would own the basic program, which would be made available to those stores that were organized, or could be organized, to use it. Each individual store would pay the service center a fee based on the volume of its transactions that were handled by the bureau.

Lennox and Lennox were approached. Would they be interested?

They had a choice. They could "go for broke"—take a chance, put in the time and effort to work out a basic program for the NRMA in the hope that eventually they would get the assignment. The reverse side of the coin was that they were a small, local firm; they were not nationally known as a data processing center; they were not centrally located; and they had no branches. Furthermore, and perhaps as damaging as anything else, they had only one computer, the medium-scale 390, which could not conceivably handle the records of a great number of stores.

Moreover, if they did not get the job, all the time and expense spent in preparing a program for NRMA would be in vain. Lennox and Lennox would be in exactly the same position as any other of the service centers that had sought the contract unsuccessfully.

It was a major decision, and the decision was yes. The three partners decided to take the chance, reasoning that their experience in working on the processing of records for Garber's and other stores gave them some advantages. They met with NRMA and undertook to prepare a program with the association, with the clear understanding that the association committed itself to nothing.

The joint work with the NRMA committee was a revelation to the accountants. Now in contact with representatives from stores all over the country, they found that there was not even a common merchandising language among them all. Stores were found that did not have either a cash register or an adding machine; all receipts went into a box, and such records as were kept were posted by hand.

Coding

So almost the first job was to set common terms on which all could agree and at least a form of coding of merchandise classifications.

The terms, ranked by position, most commonly used in inventory and merchandise reports were finally established as these:

- Store
  - Merchandise Division
    - Department
      - Classification
        - Price Line
        - Vendor
        - Style
        - Color
        - Size

An ITEM is defined as the unit on which control is exercised, and this can vary between stores and even among departments within stores. Thus a Men's Furnishing Department may reflect sales by Classification, or type of article, only. Here each ring on a sales register or each line item on a sales check, reflecting Department and Classification code numbers and dollar amount of the sale, would be considered one ITEM. In Women's Coats, on the other hand, much more detailed Unit Control records might be maintained showing Vendor, Style, Color, and Size. Here each item of merchandise is considered one ITEM.

Each ITEM handled is accumulated in one SKU (stock keeping unit). Thus if a store with twenty departments reports sales by department only, there would be only 20 SKUs. If, on the other hand, each department broke sales down by ten classifications, there would be 200 SKUs, etc.

The system as it evolved simplified the coding problem by making it flexible enough to cover the finest as well as the roughest breakdowns.

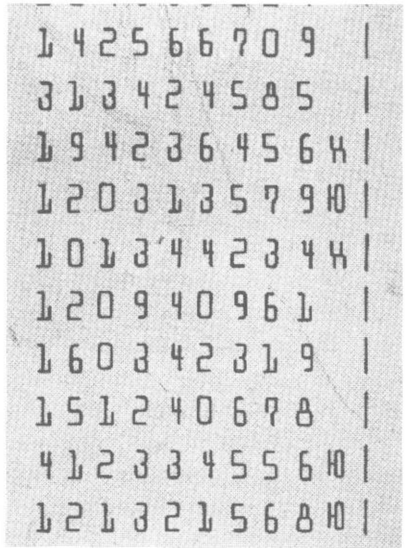
Another surprise to Lennox and Lennox was the primitive state of most smaller stores' merchandising records. A crude form of sales analysis was all that most of them attempted.

Even so, it became apparent that the accounting firm, if they were to be the data processing center selected by NRMA, would have to have a computer of much larger capacity than the National 390. An NCR 315, which could accept paper tape input like the 390, was tentatively selected. But that in turn posed new problems. Lennox and Lennox were not large enough to finance the 315, nor would they particularly need it if the NRMA project did not materialize. An agreement was worked out with National Cash whereby the larger computer would be delivered on a lease-purchase agreement if the NRMA work went to the Staten Island firm.

All of this planning took the better part of a year—and still no final selection of a data processing center had been made. And, as more companies had become aware of NRMA plans, the competition grew hotter. Other stores which had some experience with other data processing centers advanced the merits of their entries. To add to the confusion, National Cash Register, the same company which made the equipment selected by Lennox and Lennox, offered a basic and quite complete accounting package for small retail stores through its regional data centers and put all the publicity behind it that it could.

The NRMA electronics committee that was to make the final selection of the data processing center gave only one reassurance: Cost of the service was not the only consideration, although it was important. However, all other things being equal the CPA firm would not be ruled out of the running unless the price they quoted was out of line with that of the lowest competitor.

Lennox and Lennox gave an estimate based on minimum numbers of items to be processed for each store and the quantity of reports required by the stores. Under their program, each participating store would furnish data in the form of punched paper or optical character font tapes prepared at the store via cash register, adding machine, or accounting machine. If the form used to collect data was punched paper tape, such tapes would be fed directly into the computer on paper tape readers; if the data were in the form of optical font characters, the tapes would be converted by optical scanner to punched paper tape at Lennox and Lennox. Each store would be started on Report 1, a weekly sales report, and then given Report 2, (see pp. 87, 88) a monthly sales and inventory report. Four other reports would be optional.



This is a sample of type which may be optically scanned, and which is also legible to humans. The scanner reads as a human does, from left to right, but it does so at a much higher speed—26 lines a second. The reading head identifies each symbol by matching each vertical line in the upper and lower portions of the individual character with a zoned configuration of the character stored in its memory.

In January of 1965, the NRMA announced their decision. The data processing center chosen was Lennox and Lennox.

Now, three months after the start of the program, Lennox and Lennox are processing records for twenty stores. Installation procedures are being prepared for twenty-seven more, and a total of 102 stores are currently at one stage or another in their plans for an EDP installation. And, as staff time is available, additional stores will be added. The potential number is enormous. The Smaller Stores Division of the NRMA has 4,300 member stores and specialty shops, and the total NRMA membership approximates 7,500 member stores.

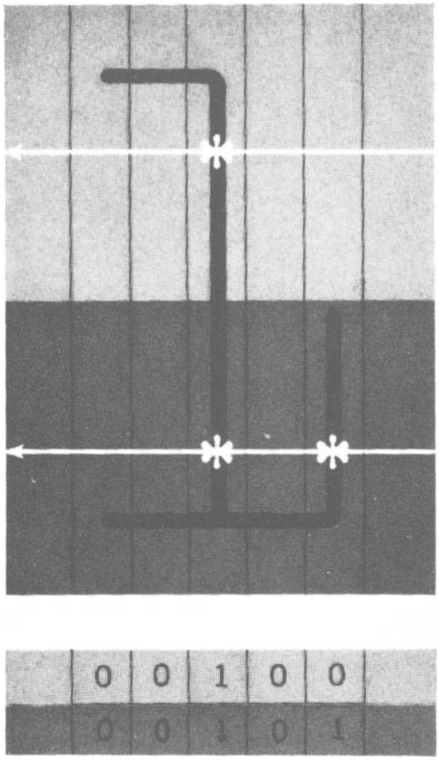
Not all of these, of course, either qualify for or necessarily want data processing services. Some are much too small to require it; others cannot fit their procedures to the NRMA program or do not have the necessary equipment of their own to produce cash register or adding machine tapes, which is a first essential to participating in the plan. Some—a very few—have equipment so elaborate that it cannot be used economically. One optimistic candidate was sure he had exactly the right input equipment, since he had just installed new cash registers that printed on their tapes dollar amount of the sale, local sales tax, money tendered, and amount of change made. The only difficulty was that this was many times the amount of information needed for merchandise reports, where the only sales analysis figure needed is amount of sale. For this client, the data processing service would have been prohibitively expensive without modifying existing machines.

On the whole, the program has proved to be valuable to stores far smaller than was originally thought possible. As originally projected, it was thought that only stores with an annual volume of at least a million dollars would be interested. Lennox and Lennox are currently preparing merchandising reports for stores varying in annual volume from $350,000 to $38 million. Cost to each store is approximately 10 to 30 per cent lower than the store would have to pay for a custom program at an individual data processing center.

Costs to a store in the one to two million dollar range are between $2,000 and $2,500 annually for data processing alone, between $3,500 and $4,000 annually for all costs—data processing, store equipment costs, and clerical labor in the stores. Initial set-up charges range between $55.00 and $400.00, plus the cost of any new equipment the store might need.

Equipment in the stores has been another surprise factor. As originally projected, the program envisaged that the majority of stores would use tape punching cash registers and adding machines and that the perforated tape would be sent to Lennox and Lennox for direct computer input. A second option was offered: The store, if it wished, could send in tapes produced with NCR figures acceptable to an NCR optical scanner. It was thought, however, that this would be used only by a very small minority of stores.

Actually, more than 50 per cent of the stores using the program have installed NOF (NCR machine-readable printing) equipment. This means Lennox and Lennox must use their optical scanner to translate the printing on the tapes to punched tape for computer entry. Therefore it raises the cost of the service to the store. However, a store can often adapt its present cash registers and adding machines to NOF type by having NCR make modifications, whereas buying new tape punching



The symbol "1" above is recognized by the scanner by its three vertical lines—one each in the upper and lower portions of the third zone, one in the lower portion of the fifth zone. This is translated by the scanner as the figure "1."

equipment or attachments for present machines would be considerably more expensive. Most merchandisers would prefer to pay higher processing rates and use their capital for the goods they can sell.

This was the least of the surprises. Far more serious has been the problem of transmitting the information. Originally, when it was thought that punched paper tape would be the stores' most common medium, stores were told they could use Data-Phone or the mails to send their data to Lennox and Lennox. The mail offer still holds good, but Data-

Phone—which transmits punched paper tape information by electrical signals that produce an identical tape at the receiving end—is useless with information that must be optically scanned. The accounting firm has had to make an arrangement with NCR by which the NRMA program will be run at regular NRMA rates by West Coast or Deep South NCR centers for stores with NOF equipment that feel distance makes the mails impracticable. Bell System engineers are now working on this problem so that eventually it will be possible to transmit visual information over a Data-Phone, but to date they have not made the solution available.

Sources of the data sent in to Lennox and Lennox depend on the accounting practices already in existence at participating stores. Some very small stores use only a very simple coding system and a tape punching or optical font printing cash register, and all hard copy reports are based on this information. A slightly larger store might use a few such cash registers and also a tape punching or optical font printing adding or accounting machine in its back office. A quite large store is likely to use any combination of paper tape or optical font cash registers plus back office input machines. The system can accept input data from any and all of these machines.

With these data Lennox and Lennox can give each participating store a sales report and a sales and inventory report (Exhibits 1 and 2, pages 87, 88) for the time period the store finds most useful. As information is stored in the computer files about any particular store it will become possible to give a complete accounting picture covering past periods of time for that store.

Many stores have such a simple classification system that they can get all the information they need for merchandise orders and detection of trends in sales from Reports 1 and 2 alone. Others, however, with elaborate systems covering thousands of items, will have a degree of control through more sophisticated reports never possible before.

Although technically the program is available to any NRMA member store, in reality some limits have to be set. Some stores simply do not have enough basic information, or accurate enough information, to use the program. Other stores have a system of their own which cannot fit into even the very liberal limits set by the NRMA plan. Some stores aren't interested, others don't have the proper data recording equipment and are unwilling to get it.

All this requires a very thorough analysis of a store's equipment and system before it can be accepted in the program. As of now, there is a three-step screening process which a store must go through before acceptance in the plan. It must first fill in a short questionnaire, which

		SALES REPORT				WEEK JAN. 24-31, 1964
	CLIENT NO. 10-002-051					REPORT # 1
CODE	PRICE RANGE	DEPT.- CASUAL DRESSES	WEEK		MONTH TO DATE	
			UNITS	$	UNITS	$
700	8.98	DRESSES-MISSY	17	153.00	61	549.00
702	10.98	DRESSES-MISSY	20	220.00	40	440.00
704	13.98	DRESSES-MISSY	25	350.00	56	784.00
706	19.98	DRESSES-MISSY	20	400.00	78	1,560.00
707	26.98	DRESSES-MISSY	8	216.00	34	918.00
708	36.98	DRESSES-MISSY	4	148.00	17	629.00
		TOTAL-MISSY	94	1,487.00	286	4,880.00
710	8.98	DRESSES-JUNIOR	22	198.00	76	684.00
712	10.98	DRESSES-JUNIOR	27	297.00	95	1,045.00
714	13.98	DRESSES-JUNIOR	21	294.00	81	1,134.00
716	19.98	DRESSES-JUNIOR	10	200.00	42	840.00
		TOTAL JUNIOR	80	989.00	294	3,703.00
		TOTAL CASUAL DRESSES	174	2,476.00	580	8,583.00

Report 1, a weekly sales report, can be compiled either from point-of-sales recording data or by back office recording. The record can be either in dollars or units or both.

is returned to the NRMA. If the answers to the questions look hopeful, the store is then referred to Lennox and Lennox, who send out a far more detailed, 17-page questionnaire to the retail establishment. This questionnaire, which is divided into eight sections, investigates the

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SMALLER STORES DIVISION — REPORT # 2

National Retail Merchants Association
100 West 31st St., New York N.Y. 10001

CLIENT NO. 10-002-051

CODE	PRICE RANGE	DEPT. - CASUAL DRESSES	B.O.M. BALANCE 1/1/64	PURCHASES $	SALES $	MARK UP/ DOWNS $	MARK UP/ DOWNS % TO SALES	E.O.M. BALANCE 1/31/64	PURCHASES TO DATE	SALES TO DATE	MARK UP / DOWNS TO DATE
700	8.98	DRESSES-MISSY	742.00	608.00	549.00	30.00	5.4	771.00	3,120.00	2,760.00	146.00
702	10.98	DRESSES-MISSY	616.00	480.00	440.00	35.00	8.0	621.00	2,390.00	2,307.00	175.00
704	13.98	DRESSES-MISSY	1,320.00	925.00	784.00	49.00	6.3	1,412.00	4,625.00	3,820.00	250.00
706	19.98	DRESSES-MISSY	3,214.00	1,726.00	1,560.00	179.00	11.5	3,201.00	8,630.00	7,800.00	898.00
707	25.98	DRESSES-MISSY	2,087.00	1,100.00	918.00	149.00	16.2	2,120.00	5,420.00	4,582.00	750.00
708	36.98	DRESSES-MISSY	1,485.00	610.00	629.00	57.00	9.00	1,409.00	3,080.00	3,050.00	294.00
		TOTAL MISSY	9,464.00	5,449.00	4,880.00	499.00	10.2	9,534.00	27,265.00	24,319.00	2,513.00
710	8.98	DRESSES-JUNIOR	700.00	520.00	684.00	42.00	6.1	494.00	2,600.00	3,542.00	210.00
712	10.98	DRESSES-JUNIOR	1,493.00	1,100.00	1,045.00	84.00	8.0	1,464.00	5,625.00	5,225.00	418.00
714	13.98	DRESSES-JUNIOR	1,970.00	1,320.00	1,134.00	130.00	11.4	2,026.00	6,700.00	5,570.00	647.00
716	19.98	DRESSES-JUNIOR	2,143.00	1,008.00	840.00	60.00	8.1	2,251.00	5,030.00	4,100.00	301.00
		TOTAL JUNIOR	6,306.00	3,948.00	3,703.00	316.00	8.5	6,235.00	19,955.00	18,437.00	1,576.00
		TOTAL CASUAL DRESSES	15,770.00	9,397.00	8,583.00	815.00		15,769.00	47,220.00	42,756.00	4,089.00

Report 2, a periodic sales and inventory report, shows purchases, sales, and markdowns at retail prices for the period covered, as well as retail value of inventory categories at the end of the period.

store's merchandising pattern, its accounting methods, and the type of equipment it is currently using.

When the store completes this phase of the program, it is then visited by a Lennox and Lennox staff member. This step would be essential in any event in order to prepare the store for absorption into the system; it has also proved necessary to learn whether the answers given to the questionnaire were correct. Often the written forms are filled in by the store president or controller who honestly believes his store is doing things a certain way. Investigation often shows that the method he has described exists only in his mind, or, at best, in an operating manual that is completely ignored by store personnel.

If this should be the case, or if the store's methods and equipment need major alterations to fit into the NRMA pattern, suggestions are given for such changes. When the changes have been made, Lennox and Lennox will return to the store for a re-evaluation. When such necessary changes are really extensive and require outside help over a period of time, the store is advised to consult its own CPA in adapting its accounting methods to the NRMA pattern.

A store that is in relatively good shape will be accepted by the firm but there will always be final adjustments that must be made. Wiring diagrams for the store's mechanical equipment must be compatible with the NRMA program; the accountants design these individually and supply them to the manufacturer of the machines.

Personnel problems

The accountants have had their own difficulties with the program, too. A real trouble has been enough personnel. Even though stores that do not fit readily into the NRMA program are advised of the changes that must be made and told to work them out for themselves or with their own CPA, nevertheless the work load for a staff as small as that of Lennox and Lennox has been overwhelming. And people skilled in and knowledgeable about computers are in short supply and high demand. Still, the firm is adding them just as fast as they can. They have managed to get them by offering extremely attractive incomes. They have devised a fairly elaborate profit-sharing system which makes it possible for non-CPAs to earn nearly as much as partners, even though they cannot, of course, become partners.

Another difficulty has been equipment. Lennox and Lennox had laid their ground with NCR when the NRMA contract first seemed a possibility and had confirmed their order as soon as they were sure of doing the NRMA work. But the inevitable delivery delay prevented getting the 315 and optical scanner until May of 1965, while they had to process data from participating member stores from January

1964, on. Their solution was to put the 315 programs on the 315 at NCR's New York data center. But every computer must always have a backup unit, an identical machine that can accept the same program, process it, and come out with the same output. Then, if for any reason the original machine breaks down, the program can be maintained with a minimum of delay as long as the computer owners have a standing exchange arrangement. Since there are a number of 315s in the New York area, this doesn't seem much of a problem.

Actually, it was a very serious one as Lennox and Lennox learned when the 315 at the data center did break down. The 315, like most modern computers, is a modular machine, with varying peripheral equipment conformations of varying capacities and speeds. Lennox and Lennox, which anticipated a relatively simple program for a large amount of information from a large number of stores, had decided that they would design a system with a large "core" memory for sorting data, with updating files maintained through magnetic tape storage on 33KC Drives. Compatibility in this instance, for back-up, means that it is necessary to find a similar unit of the same internal memory "core," as well as external magnetic tape drives in the same quantity and speeds. They finally found identical machines in Philadelphia and Hartford.

Another unforeseen equipment difficulty showed up at the store level. Although many existing cash registers or adding machines can be adapted for use with an optical scanner simply by replacing type bars with optical font type bars, the mechanisms that activate these bars do not always strike with equal pressure in very old machines. So at the beginning optical tapes were coming into Staten Island that could not be read by the scanner. That difficulty has been solved now by adjustments in the store, but it illustrates the range of unexpected troubles that can occur in a program like this.

How could Lennox and Lennox, with such a small staff, write six programs for the six merchandising reports in the short time span covered by the entire NRMA venture? The answer is: They didn't. They knew such programs could be written; after all they had already written them for their old 390 for Garber's on Staten Island. So they concentrated on Reports 1, 2 and another optional one, which were completely rewritten for the 315. Then they programed other Reports knowing that only the first reports could be prepared for any store anyway until the store had gathered one year's data required for the inventory reports, seasonal planning reports, and the open-to-buy reports. By the time a store has been operative for the required period of time, all reports will be available for NRMA members.

All of this has been a lot more expensive than the 390 installation. All expenses for the 315, the optical scanner, and data processing personnel will run to $251,000 for a twelve-month period. Still Lennox and Lennox have charted their course and so far see nothing to regret. They now have five other associations, similar to the NRMA, for which they are devising programs, and they have turned down one. They eventually hope to do association work and their own and other CPA financial statement work almost exclusively.

Their confidence in the future of their accounting-data processing center is perhaps best illustrated by their actions: They already foresee the day when the one 315 will be inadequate to meet their needs. They have therefore already begun to explore the newest generation equipment which is more powerful and can do several jobs at one time.

CHAPTER

4

Auditing the Computer

Audit Around or Through the Computer?

Using the Computer as an Audit Tool

Computer Assists Inventory Check

Internal Control and Audit of Real Time Digital Systems

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Audit Around or Through the Computer?

THE FIRST ATTRIBUTE that an auditor faces as he looks at electronic data processing is the changed nature of the audit trail; that is, the trail which is available to show how data from a document arrived in some summary figure in a general ledger account balance. He finds that it is not only possible, but very much a fact, that, between the data on a document and the final information which is printed out, the accounting steps have been processed and stored in or on material that is not visible to the human eye. For example, accounts receivable transactions and balances with related customers' names may be stored as magnetic spots on a tape. In turn, "journals" reflecting the current sales and cash receipts transactions used for posting (in computer parlance "updating") the accounts receivable records are likewise not visible to the human eye. Thus, both the journal record and the ledger record may not be audited by comparison with documents in the customary manner.

The modern method of electronic data processing is to utilize either tapes or discs on which to write information by means of an electrical charge. In the recent past, many computers continued to utilize traditional punched cards for processing as well as storage of information. Thus, the predicted auditing problems did not arise. Another factor in the changed nature of the audit trail is that, unless print-outs are specifically arranged for, most systems provide for erasing from the tapes, after a relatively short period, the interim recording steps which were taken. Thus, it may be impossible to utilize reference folios and recorded entries to trace from end products back through computer tapes to source documents.

When we leave the question of the audit trail of a computer, the next attribute which should duly impress and concern us is the power of the computer to do things. The computer has phenomenal ability to answer your inquiries as to the status of any information which is in its memory. (The word memory is being used to include all the data which have been stored in a manner that is readable by the computer.)

For example, if inventory records are maintained on the computer, in a relatively short time an inquiry worded in proper form can elicit the amount of inventory which has not been used for three months, six months, nine months, etc.; the items of inventory which are over a certain dollar amount and those which are under; the items of inventory which are related to current bills of material and those which are not; the items of inventory whose unit prices changed from the preceding year and those which did not; the items of inventory which are larger in quantity than those of some preceding time, and so on ad infinitum.

Another power of the computer is its ability to process or reprocess complete activities in less time than it would take to make a 1 per cent or 2 per cent test. For example, the computation for inventory extensions can be completely reprocessed in far less time than it would take to recompute a small portion of the extensions. Finally, one should be impressed with the power of the computer to carry out the audit steps which auditors may have dreamed about performing but would have found impossibly lengthy. We shall later refer in more detail to this phase of the power of the computer.

Looking further into the attributes of the computer, there are, beyond the two mentioned previously, some interesting and significant things to observe. The computer has been proven without any doubt to be far more accurate than either people or any previous machines in performing mechanical operations with data. As we shall see later, aside from the inherent nature of a computer, the accuracy results from both built-in checks and checks that are programed in using the computer.

Next, electronic data processing reflects a concentration of many processing steps into one department. Thus, the traditional internal control that is made available by the separation of duties in the recording process is eliminated. We shall discuss later the question of whether or not there is an adequate substitute.

Another extremely important attribute which needs to be considered as to its impact upon auditing is the concentration in one place of traditional accounting data along with operating data. In computer parlance, this is referred to as integration on one record of everything related to that particular piece of data. A record in this case means the physical space on a tape or a disc which is occupied by related data adjacent to the introduction of similar data concerning different items.

Audit questions

Consideration of the foregoing described attributes of electronic data processing raises the following audit questions:

1. Do we lose control of our ability to test transactions?
2. Is internal control weakened?
3. Are new auditing tools required to cope with the changed conditions?
    a. Is a technically oriented review of computer programs required?
    b. Can we use test decks to substitute for traditional systems testing?
    c. Do we need to worry about unauthorized access to computers?
    d. Is a new kind of internal control survey required?
    e. Must we participate in the program design phase in order to audit effectively?
4. Are new audit standards being established because a new audit tool has been acquired with more power than was previously available?
    a. Are complete reviews to be made in lieu of testing?
    b. Are we to make new analyses such as (to be more fully described later) determination of the nature of all additions to and eliminations from a payroll, all changes in rates, etc., for a six-month period?
    c. Do we need to make inquiries as to status of accounts of a nature not previously ascertainable?
    d. Should we utilize selection by the machine of samples statistically designed so that the item selected could then be intensively studied as compared to traditionally less intensive auditing?

The foregoing list of questions raises some formidable issues. The profession as a whole has not come out with any firm guidelines as to its position on these questions. Certainly, in the limited space of this paper, it is not proposed to attempt to answer all of them definitively. We will, however, endeavor to elaborate in a preliminary way on some of the most pressing questions.

Considering the facts and questions presented, the most important task which emerges for the auditor is to meet the challenge that has been created by the increased power to audit with the aid of a computer. Conceivably, if the profession in general moves ahead to increased and better audit coverage through the use of the computer, then anyone who has overlooked something which might have been uncovered by such better methods may have legal liability. In other words, merely to hold a defensible position, it is necessary that we improve. The defensive approach that we can audit "around the computer" is not a satisfactory position. This position, of course, has been taken by many auditors who say, "We managed to check the inputs and outputs when punched cards came along; we can do the same with computers."

This paper submits that a new dimension in auditing has been made available and that finding a way not to let it impede us is not satisfactory—we must find a way to utilize for positive goods the tool which is available. We need to reconsider our position regarding the depth of all tests of transactions heretofore made. On the other hand, we need to reconsider the breadth of the tests of transactions in the light of the integration of records existing on computers.

In "Internal Controls," a booklet published by the American Institute of Certified Public Accountants in 1949, the committee on auditing procedure defined internal control as the "methods and measures adopted within a business to safeguard its assets, check the accuracy and reliability of its accounting data, promote operational efficiency, and encourage adherence to prescribed managerial policies." It was further stated that ". . . internal control extends beyond those matters which relate directly to the functions of the accounting and financial departments."

The definition has raised challenges resulting in an attempt to define separately those matters which are "administrative" as compared to those which are "financial," and to state that as auditors we are directly concerned only with "financial" control. If this distinction can be held valid when the records are separated—and this is questionable—the distinction will be much more difficult to maintain when the records are combined. Furthermore, from a point of view of *opportunity* for services, the accountant should hardly ignore information which is under his nose while he is pursuing what he thinks is his legitimate course. To repeat: a re-evaluation must be made of the purposes of our test of transactions.

Much has been said—particularly by computer technicians—to the effect that the only way to audit computer records is to review the computer programs. They point out with infallible logic and strongly accusing words the benefits which could be derived from such a review.

This, of course, raises some serious questions for auditors since a review of computer programs presumably involves extensive technical knowledge ordinarily not possessed by public accountants.

Does this mean that the audit function needs to be released to a new breed of specialists?

The objective of reviewing the program steps or so-called logic flow charts is a desirable objective but does not appear to be a practical thing to do. It is not unusual to find that a program for a payroll alone contains one hundred thousand steps. Furthermore, there is no assurance that, if these steps were reviewed through examination of the flow charts, the programs would, in fact, follow the flow charts. In my opinion, the answer to reviewing the performance of a computer is utilization of test decks, not reviews of programs.

A test deck is utilized by the program designer to ascertain whether or not a computer is functioning as intended. We, in turn, could and should devise in computer-readable language a list of transactions for the computer to process. We should endeavor with this list to ascertain how the transactions would be handled, either rejected or accepted, and, if accepted, the effect which they have upon the end results. These transactions would have to be so designed that each and every possibility for breaking down the program could be tried. Such a check utilizes the power of the computer to read the program steps. Secondly, assurance is attained that the program is the one being used rather than the one that is pictured on a piece of paper.

In order to prepare an effective test deck, there are two things which the auditor needs to know or understand. First, he should attain complete knowledge, by means of a list, previous training, etc., of the program checks which can be written into a computer program. As referred to heretofore, we previously depended upon separation of duties in the recording process in order to increase our sense of assurance that the recording was accurate. Program checks fully and adequately replace the "separation of duties" concept as a means of assuring accuracy.

For example, the program can request the computer to compare the average unit cost being carried for an inventory item after processing a new receipt of merchandise and before such processing. The program can further dictate that, if such price changes by more than a given amount, the transactions should be printed out. This, of course, is protection against all kinds of errors relating to the processing of a new receipt. Or the program, in order to help evaluate whether or not code numbers are accurate, may compare a unit price of a receipt with the unit prices of the preceding items. If the unit price of the new item differs by a certain amount, the machine will refuse to record the item. The program may require that certain comparisons be made of numerical codes placed at the beginning of the program with key data on the beginning of the input tape in order to be certain that the correct input tape is being processed. If the comparison shows differences, the machine will refuse to process.

Other program controls can include the simple expedient of hash totals. This means that some otherwise meaningless numbers, such as invoice numbers, can be totaled by the machine to compare with the preceding total of these numbers in order to ascertain that all of the data have been processed. And so the program checks can be continued for a great many things. The auditor needs to know which of these program checks are claimed to have been built into a program and he should construct test decks to challenge these program checks.

Because the auditor needs to know the program checks which have been incorporated and because he can make a positive contribution in this area in the design of the system—as an auditor, not as a management consultant—it is important that the auditor participate at the initial steps of system design.

In addition to the auditor's need to understand program checks, there is also a need for him to understand the built-in controls that exist within the machines. These controls are there to detect the malfunctioning of the equipment. They go all the way from ascertaining whether or not it is likely that some magnetic spots have been dropped from the tape, thus reflecting incorrect information, to checking whether or not tubes have been burnt out or computations are being incorrectly performed. Knowledge of the specific controls available in the equipment is useful in order to appreciate whether or not certain controls need to be made through program checks.

Status of internal control

The next question upon which elaboration is important is the question of whether or not internal control has been weakened. Often because the definition of internal control is tied so strongly to the concept of separation of duties, there is a failure to distinguish separation of duties within the recording process from the fundamental separation required. The basic principle is that there should be a separation between those people who authorize a transaction, as well as those required to have custody of any asset acquired, from those people who record the accountability for the asset. This basic separation in accounting as well as in other functions, must be retained in order to have satisfactory internal control.

There is nothing in electronic data processing which is inconsistent with this requirement. The means for authorization and the nature of authorization, however, may become somewhat changed. For example, if under automated inventory management, a computer prints out a purchase order because an inventory item has fallen below a certain balance, this may on the surface appear to be elimination of a separate authorization. The authorization, however, goes first from the operating people to the people who have designed the program for consideration as to the factors which will permit or require a purchase. Secondly, as will be mentioned later, the control over the program should be separate from other activities in the computer room.

As has been previously indicated, the separations sought in the recording function in order to promote accuracy can be far more than offset by the built-in accuracy of the machine, as well as the program checks that can be instituted. However, the fact is that certain aspects challenge the reasonableness of data being processed—what might be expected from experienced employees cannot be accomplished by the machine. Thus the question of accuracy shifts from the problems of the processing function to control over the accuracy of the initial documents. As was pointed out, the machine can be programed to reject certain types of data. A review of the list of rejected items (mismatches) can serve to cast light on whether or not documentary control is being adequately exercised at the source.

In challenging whether or not internal control has been weakened by EDP, on the other side of the question of whether or not previous controls still exist, recognition must be given to the fact that a host of new controls need to be evaluated. We need control over changes in programs; we need control over access to handle exceptions shown by the machine either at the input stage or output stage; and we need control over when tapes can be used and for what purpose.

Often, a question has been raised as to controlling access to the processing of the machine through intervention by an operator at the console. Can the console operator eliminate posting to his account for purchases which have been made by him and his family? The potentials for such intervention are related to the complexity of the process for doing this. Separation of control over the program from the console operator increases this complexity. Subsequent balancing of data produced by the machine is another factor involved in the nature of internal control.

Another area of control that was not needed before EDP is the maintenance of records of downtime of the machine. Unlike human errors, EDP errors are not made at random, but occur in clusters when some one thing is at fault. Accordingly, an auditor's tracking of the downtime records and the reasons for the downtime can provide an opportunity for selective testing. A further significant control relates to the possibility of losing information because of a malfunction of the electrical current caused by accident or perhaps by some perpetrator's design.

All of the foregoing indicates that internal control is not weakened but demonstrates that new emphasis must be given in our review of internal control to ascertain that it be effective. First, we must shift to adding attention to our review of the control over source documents. Second, we must know more about the system than we know about how people are performing. The test of transactions under traditional conditions is based on the concept that people may not follow instructions and that instructions leave latitude for human judgment. With EDP, a probe in depth to disclose the system that is in operation is rewarding —the system will operate just as it is constructed.

Reliance on print-outs

Print-outs refer to making a visible record of data that are available from the computer. If everything that goes into and through the computer were to be printed out, the problem of whether or not audit trails exist would be completely eliminated. (This would not, however, close the book on EDP auditing problems because the fundamental question of utilizing the increased power of the equipment still remains.) We do know that any system which is designed to have complete print-outs largely destroys the benefits of having electronic computers. On the other hand, experience is showing that the print-outs provide readable information normally required by management to carry out its operating and control functions, and in some cases also provide the information needed for an adequate audit trail. This experience is limited, however, to past installations which, for one thing, have dealt largely with nonmanagement areas, such as payroll, where the activities must be printed in toto in order to develop payroll checks, etc.

At present we can expect a trend to develop towards two types of installation. First, the subject matter will deal more with management problems for which complete print-outs are not necessary and, secondly, the design of the systems can be expected to be more sophisticated in that print-outs will be limited to exceptions, that is, only those items requiring action or decision. The increased sophistication will come about because the computer will be asked to make decisions rather than merely develop undigested information to be submitted to management for decisions.

Need for advance planning

Thus, the auditor may well anticipate that under present techniques his future needs for print-outs, as well as the needs of management, will coincide less and less. Thus to the extent that he is to rely on print-outs, he will have to do far more advanced planning with the client. Otherwise, he may find that the data which he wishes printed out will have been erased from the tapes and will not be available for perusal. To accomplish this planning effectively, the auditor will need to be intimately familiar with the system.

On the other hand, it must again be emphasized that requests by the auditor for print-outs to be made only for him constitute an obstruction to the full development of the potentials of EDP. Accordingly, he needs to learn to rely more on techniques that do not require print-outs. To the extent that he is to confirm ending balances by external correspondence or by inventory observation, print-outs, of course, are necessary and the audit procedures should not be changed merely as a result of the advent of EDP. But, to the extent that auditing is directed to examining and testing the system of internal control, techniques which do not require print-outs should prove more effective both as to the ease with which they can be used and as to the depth of probing which can be accomplished.

In general, the advent of EDP has opened new potentials for doing constructive auditing work. However, whereas in the past we considered it possible to develop suggestions and recommendations from our periodic tests of transactions and to incorporate them in internal control letters, this may no longer be feasible. If a recommendation should require making a change in a computer program which could cost upwards of $25,000, the attitude might well be that the suggestion is unwelcome, or it might be challenged with the question as to why it was not made at a time that was more practical. This, of course, leads back to the concept that there should be early participation with the client in the construction of EDP systems.

Recommendations for improved controls at the inception of planning can result in control procedures that remain effective over a long period and, accordingly, large benefits can be realized. These conditions further imply that the auditors and management services people should form teams to participate in the systems design stages. This approach is consistent with the philosophy that we should render an integrated service to our clients. The client should not merely be thinking that he is getting auditing, management services, or taxes, but rather that his total problems are being handled satisfactorily.

In order to help tie together the abstract concepts expressed here, consider the facts set forth in a published article on a case study of a payroll examination. With a relatively small amount of programing time and an even smaller amount of computer running time, persons on the payroll at the end of the period were compared with those on the payroll at the beginning of the period. The changes in personnel were compared with authorizations issued by the personnel department in punched card form for additions to the payroll, and releases were similarly vouched. Changes in rates were compared with data involving rate changes as set forth in the union contract, and various other payroll activities for the period were completely and entirely checked out by the computer.

This application is just a very small example of how audit activities can be extended to cover things not heretofore considered approachable. There are many other examples of this type.

There is adequate evidence from perusal of the preceding statements that auditors will need new knowledge about the nature of data processing and that they will need to learn new techniques. This unquestionably raises the common sense question of: Are people trained to do this kind of work? Aside from the common sense question, we are challenged by the first of the general auditing standards issued by the AICPA, which reads:

> The examination is to be performed by a person or persons having adequate technical training and proficiency as an auditor.

Need for training programs

Do our people have such training in the age of electronic records? Will we be complying with these auditing standards? Training programs must be immediately re-evaluated to answer these questions.

The evaluation of a training program should recognize that, aside from dealing with specific auditing techniques, the program should cover the following:

1. An indoctrination into the general nature of a computer including an understanding of programing.

2. An understanding of each of the possible program checks and of the built-in machine checks.

3. A sufficient indoctrination into the nature of flow charts and block diagrams so that the auditor will be able to make reference to them in order to identify program checks.

4. A sufficient exposure as to the nature of test decks and the manner in which they can function so that the auditor can participate in developing such decks for the types of transactions required for checking. Presumably, the actual means of translating the transaction into machine-readable language and performing a test run will require coordination with technicians within our staff or from the company.

The story of the impact of EDP upon auditing may be quickly summarized as follows:

1. Although previous threats as to the impact of EDP were not realized, the threat is now here.

2. The threat is primarily one that calls for an improvement in growth in our auditing techniques so that we do not fall backwards by merely standing still.

3. The job is not at all insurmountable and perhaps not even as difficult as many people make it sound, but this in no way means that what we are doing today is adequate.

S. LELAND DILL, CPA AND DONALD L. ADAMS, CPA

Using the Computer as an Audit Tool

(Example—audit of a stockbroker)

ONE OF THE GREAT CHALLENGES facing the auditor today is the ever-increasing utilization, by his clients, of electronic data processing equipment. This challenge is defined in the premise that the auditor should not "audit around" computers but should use the computers to improve and expand his auditing skills. With the advent of high-speed, medium-cost computers, many companies in every industry have replaced their conventional unit record (punched card) installations with computers.

With its unlimited capacity for the rapid processing of great volumes of data, the computer has proved to be a particularly useful tool for the stockbrokerage industry. In the last five years, virtually all of the larger stockbrokerage firms have installed computer systems of one type or another. The auditors of these firms and other firms which are in the process of converting to EDP have been presented with the problems inherent in conducting an audit "through" rather than "around" the client's computer. An explanation of how some of these problems were solved may also find applications in other industries.

To understand the special problems, however, one must have an understanding of the nature and purpose of the stockbrokerage audit. All stockbrokers and dealers are regulated by the Securities and Exchange Commission. The SEC, among other things, is responsible for the administration and enforcement of the Securities Exchange Act of 1934. A section of this act requires all stockbrokers dealing with the public to furnish, once in each calendar year, an audited report of financial condition in the form of a financial questionnaire. The financial questionnaire, called Form X-17A-5, consists of two parts: Part I, which calls for the answers to fourteen questions; and Part II, which calls for specified supplementary information generally consisting of the details supporting answers to questions in Part I. Stockbrokers who are members of national securities exchanges, such as the New York Stock Exchange, are subject to regulation by these exchanges in addition to regulation by the SEC. The New York Stock Exchange, for instance, requires an audited financial questionnaire from each of its members once in each calendar year. This questionnaire consists of three parts. Parts I and II are identical to the questionnaire required by the SEC and Part III calls for certain additional information. One basic difference between the audit of a New York Stock Exchange member firm and of a nonmember firm is the Exchange requirement that the audit be on a surprise basis. The SEC does not require a surprise examination. In general, the other national securities exchanges have the same financial reporting requirements as the SEC and a financial questionnaire meeting SEC requirements is acceptable to these exchanges.

The instructions for the financial questionnaire stipulate the auditor must prepare the answers and express an opinion thereon. This procedure differs significantly from the audit of a commercial enterprise where the financial statements are prepared by the client and the auditor performs such tests and auditing procedures as he considers necessary to enable him to express an opinion on the statements. In addition, the preparer of the financial questionnaire must comply with specified audit procedures known as "regulations prescribed for audit" which are set forth in the questionnaire.

We see then that the auditor of a stockbrokerage firm is required to accumulate all pertinent data as of the audit date, place this data under his control, perform certain audit procedures on this data, and then classify the audited data in the form of answers to the questionnaire. In some cases, his audit must be performed on a surprise basis.

About a year ago, several of our larger stockbrokerage clients notified us of their intent to replace their unit record equipment with magnetic tape computer systems. Several months would elapse before these clients could expect delivery of the computers and during these months we developed a plan of action. Our first step was to attend specialized courses offered by the computer manufacturer. The knowledge we gained from the courses enabled us to correlate our existing unit record audit procedures with the capabilities and limitations of the computer. It gave us an insight as to the problems we might encounter and it also enlightened our thinking as to the use of computer techniques in other phases of our audit practice.

Familiarity with the capabilities of computers opened a whole new world of ideas as to how we might use the computer as an audit tool. Why not develop programs which could be used to verify any ledger account involving an allocation to future periods, or a program to evaluate the clerical accuracy of inventories? How about programs which would provide for the printing of accounts receivable and payable confirmations on continuous form envelopes or others which would match inventory test count cards against the client's final inventory figures and prepare a list of exceptions?

The more involved our thinking became, the more we realized the only limitation placed on the auditor in the use of computers as audit tools is the limitation of the auditor himself because of his lack of knowledge in the computer field. Ultimately, the computer-oriented and trained auditor should be able to develop simple audit programs designed to fit specific tasks which are now performed manually. This orientation and training will be time-consuming and costly, but in the final analysis it may be the only way to completely eliminate the audit "problems" created by computers.

After satisfactorily completing the computer manufacturer's specialized courses, we addressed ourselves to the task at hand. From the outset we recognized that a significant problem had to be overcome. This problem involved the cost of programing our audit procedures. The computer programs being written by our clients covered daily bookkeeping procedures and did not produce information in the form required to prepare the answers to the financial questionnaire. To prepare and test individual audit programs to fit the differences in coding and format of each of the several clients would require many man-hours. Another problem was timing. The client would need many months to convert his present system to a full computer application. These months would be spent in programing, form revision, and training his personnel in the operation of the computer. If we were to conduct a surprise audit during these transitory months, we would have to be prepared to deal with a partially integrated system with the possibility of certain basic records being in the form of unit records (punched cards) and others in the form of magnetic tape.

We decided the solution to both these problems was to formulate a general computer audit program. This audit program could be used on any stockbrokerage audit and would consist of computer programs which could handle either unit record or magnetic tape input and output. The general program concept would take advantage of the one basic area of commonality for all stockbrokerage firms: the financial questionnaire. Since the output of the various computer programs could be defined as the specific questionnaire answers, only the input would differ from client to client. We could translate all input data to our formats and achieve a degree of flexibility which would enable us to complete our standard audit program before our clients had completed the conversion of their records. Further, these translation programs (used to rearrange client data) would take less programing time than creating individual audit programs for each client and would serve to reduce our overall programing cost.

Once we had selected the basic approach we would follow, the information-gathering phase of the job began. Audit workpapers, particularly permanent file systems and procedures material, provided a wealth of information on the details of different stockbrokerage accounting systems. By relating each client's system to the specific audit steps performed and tracing the audit steps through to the completed questionnaire, it was possible to develop a feeling for the degree of commonality inherent in stockbrokerage accounting.

After we had outlined the basic records we could expect to find in any stockbrokerage house, and made note of those records we were likely to find, it was necessary to investigate the available computer hardware in greater detail. By this time, our clients had received delivery of the same basic make and model computer and several others planned to install similar equipment within a year. Although the clients who were our prime concern were using the same basic equipment, we had to find out the details of memory size (capacity), input-output devices (card readers, card punchers, printers), and special features (automatic multiply or divide, data editing). In addition, although we had a good working knowledge of our clients' current systems, we had to know the timing and direction of the changes to be made as more applications were placed on their computers. The timing was particularly important because of the surprise element of our forthcoming audits.

Computer installation questionnaire

To solve these dual problems, a computer installation questionnaire was prepared. Our questionnaire covered the following points:

A. Present status of computer installation
   1. Complete or partially complete?
   2. Status of basic files

a. Cards or tape?
b. Target dates for conversion to tape

B. Configuration of computer installation
1. Memory size
2. Number and type of magnetic tape drives
3. Special features
4. Programing system or systems used (particular "language" used to write programs)

C. Basic record files planned for completed installation
1. Card, tape, tickets, other
2. Attach layouts showing how data is organized on records

D. Detail record files planned for completed installation
1. Card, tape, tickets, other
2. Attach layouts showing how data is organized on records

E. Chart of accounts and other codes
1. Present—attach list
2. Planned—attach list

It was essential we receive complete and correct answers to our questionnaire in order to plan an effective general set of audit computer programs. Consequently, the questionnaire was hand-delivered to each of our clients and thoroughly discussed with their installation personnel. When we were sure the client knew what we wanted and understood its importance, we left the questionnaire to give them ample time to furnish all the needed information. When the completed forms had been returned, we could consider our basic information was now complete.

Before we could begin to outline our program and construct overall system flow charts, we had to decide on the standard computer configuration we would use in writing our programs. Since we had concrete information covering several clients, we could easily select a common set of specifications which would fit their machines. Unfortunately, our problem was not quite so simple. Programing would be a considerable undertaking and we wanted it to be workable in the future. As a result, we had to make certain projections concerning the future computer plans of our clients and future developments which might affect our smaller clients.

As the best possible compromise, we decided to base our plans on a computer with: 8,000 character memory; four magnetic tape drives punched card reader-punch; high-speed printer.

In addition, we decided to program all multiply and divide operations, since we could not count on the presence of automatic multiply/divide in all our client computer installations.

Our next decision was the selection of a programing system or language we would use in writing our machine instructions. Of the systems available, COBOL[1] seemed the most attractive, since a COBOL program can be compiled to run on any computer produced by a major manufacturer, but it is not a completely proven system and we wanted solid, dependable results. FORTRAN[2] offered many of the advantages of COBOL, since it is also a "universal" language, but it is not well-suited for the large volume, small calculation jobs typical in a stock-brokerage application. SPS, AUTOCODER, and AUTOCODER/IOCS[3] were also examined. After considering all the technical aspects and weighing them against the desired results in terms of accuracy and speed, we selected AUTOCODER/IOCS because it simplifies the programing necessary to read and write magnetic tapes. Although this particular system is far from ideal because it wastes large amounts of storage, it was the best compromise we could achieve.

When our computer capabilities and programing system were standardized, we began the job of deciding which basic audit procedures we would perform on the computer. Over the years, a standard program had been developed for use on our unit record machine audits. This program became the foundation on which our computer system would be built. We began a routine of flow charting and criticism. It seemed, at first, we would never get past the flow chart stage, but it was essential for us to solve all of our problems on paper as completely as humanly possible before we began the actual coding phase. Finally, we developed an approach which seemed to withstand every attack by the other members of our audit staff. The final flow charts were drawn up, a list of required programs was prepared, a list of tape and card record files to be used was compiled, and files were assigned numbers.

The next step was the design of file layouts. Record sizes, field sizes,

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[1] *COBOL (COmmon Business Oriented Language), is a universal programing language. It represents an effort to produce an English-like programing language which can be used on many different computers even though they may be products of different manufacturers.*

[2] *FORTRAN (FORmula TRANslation) is a system devised originally for the IBM 704 but now available for many computers. Programs are written as a series of mathematical equations.*

[3] *SPS, AUTOCODER, and AUTOCODER/IOCS are all IBM-developed languages which remove much of the detail programing burden from the shoulders of the programer and put it on the computer itself. As a result, the programer can concentrate on the logic portion of the program.*

coding requirements, and layout had to be carefully considered. Once more, we had recourse to our permanent files and questionnaires to make sure that the largest field size used in any record by any client would fit into our standard file layouts. For example, if the largest field set up by a client to record quantity was six digits, we would set aside eight digits in our records to allow for expansion. To accomplish our requirements, it was necessary to design comparatively large records, but we had no choice. Our whole system was based upon having the ability to convert *any* client's record to a standard format for processing through all our programs.

A system of standard codes was more difficult to develop. We had to build into our coding structure all the indications needed to differentiate between various types of records in order to process them through our programs. Distinctions had to be made between cash accounts and margin accounts, customer accounts and partner accounts, and between all the different types of short side or "location" accounts for purposes of counting and other audit verification. These standard codes had to be incorporated into our records, but at the same time we could not destroy the client's coding. To some extent, coding could not be planned in advance, but had to be developed as required in the standard programs.

Report formats had to be designed and related to our audit requirements. We planned to make every hard copy printout of maximum value to our audit staff. Formats were standardized whenever possible to simplify the auditor's job. In any audit, one of the hardest jobs is getting a feeling for the client's system. By developing our own system, we would provide standard records for each major stockbrokerage audit. Report formats were also designed to coincide with our standard workpaper layout. Every page of output is assigned a workpaper number, and is imprinted with the client's name, the audit date, the name of the accountant preparing the run, the date run, and the report title. A standard program subroutine was written and is incorporated into each of our programs which generates a written report. The variable information for each audit is entered into the computer's memory from a single punched card and is automatically emitted at the top of each printed page.

Every step made and every decision taken during the course of our work was fully documented. We considered documentation essential in order to leave a broad trail which would permit anyone with a knowledge of computer operations to take over the actual operation of a computer audit. All programs were flow charted before they were coded into actual machine language. Record layouts for tape and cards were drawn up and collected into a layout book. Program listings were indexed and bound into book form. Machine operation sheets were prepared for each program and placed in a run control book. A job notebook was begun and used to record all information collected and the results of day-to-day decisions.

Since we do not have any data processing equipment in our New York office, it was necessary to obtain machine time from our clients. We received excellent co-operation from everyone we approached. One client, with a very tight computer schedule, gave us a great deal of support with his unit record (punched card) equipment and was particularly valuable to us in the area of keypunching. Another client permitted us to make extensive use of his computer installation after regular working hours. From the physical operations standpoint, our program could not have been completed without the wholehearted and generous support we received from our clients.

Our audit system is made up of forty-two general computer programs. Most of these programs are used to sort, classify, and list data for the purposes of audit confirmation, or physical count. Only two programs perform completely automated audit steps, but these programs cover the two most exacting tasks in any stockbrokerage audit: classifying customers' accounts to answer question 6 in the financial questionnaire, and verifying that the maintenance margin requirements are being observed on customers' margin accounts.

Question 6 on the financial questionnaire requires the classification of customers' debit and credit money balances, and long and short security values into six basic types:

6A—Cash accounts
6B—Secured accounts
6C—Partly secured accounts
6D—Unsecured accounts
6E—Accounts with credit balances having open contractual commitments
6F—Accounts with free credit balances

In our program, as each customer's account passes through the computer, its money and security balances are stored. When the account has been completely read into memory, the computer enters a decision matrix (a table in which decision based on two factors can be determined by reference to the point at which the two factors cross) and selects the proper class. Totals are then added to accumulation areas for this class and data from the next account is read. In a simplified form, our decision matrix is constructed as shown on page 114.

After all the customer accounts have been analyzed, a final report is printed summarizing the totals for each class. Additional runs through the computer produce detail listings by account for 6A, used to vouch subsequent transactions; 6C and 6D, for investigation; and 6F, for further action by the client's margin department. Automation of the question 6 audit procedure has eliminated the time-consuming task of examining statements, selecting a class, placing each statement in a pile, and the compilation, by adding machine, of the four report components of each statement: debit and credit balances and long and short security values.

In checking the maintenance margin on customers' 6B accounts, we observe the margin requirements of the New York Stock Exchange which state:

> (b) The margin which must be maintained in margin accounts of customers, whether members, allied members, member organizations or nonmembers, shall be as follows:
>
> (1) 25 per cent of the market value of all securities "long" in the account; plus
>
> (2) Two dollars and fifty cents per share or 100 per cent of the market value, in cash, whichever amount is greater, of each stock "short" in the account selling at less than $5 per share; plus
>
> (3) Five dollars per share or 30 per cent of the market value, in cash, whichever amount is greater, of each stock "short" in the account selling at $5 per share or above; plus
>
> (4) Five per cent of the principal amount or 30 per cent of the market value, in cash, whichever amount is greater, of each bond "short" in the account.

Since unit record equipment did not have enough decision making ability to compute margin requirements according to the actual rules, an approximation method was used. The debit money balance was

DECISION MATRIX

Market Value of Securities	Money Value Classification		
	Debit	Credit	No Money
Long value only	A-B-C	E-F	E-F
Short value only	D	A-B-C	D
Long value equals Short value	A-C	A-B	A-B
Long value does not equal Short value	A-B-C	A-B-C	A-B-C
No securities	D	E-F	-

multiplied by 134 per cent and compared with the security value long. If value long was greater, the account was considered as having met the margin requirement. A similar test was applied between value short and credit money. While not exact, these methods were a practical means of checking the maintenance margin. Even with unit record systems, the verification of maintenance margin requirements on one of our major clients requred two and a half days. Using the more flexible and versatile abilities of the computer, we are now able to check margin requirements in exact accord with the rules and do it in about two hours. In this instance, we have gained accuracy and speed by using the full benefits available from a computer.

In spite of the wide range of general programs available to us, it is still necessary to write translator programs for each individual client in order to convert his records to our formats and codes. Depending on the client, from four to eight translators are required. These programs are fairly easy to write and in most cases can be completed in a total of twenty to forty man-hours. Although presenting no inherent programing difficulties, these programs have proved to be a source of trouble, because of client's failure to give us a complete explanation of their layout and coding. A man who has daily contact with a system is very often prone to forget its minor quirks. When run through a translator program, these minor quirks often emerge as major errors.

So far, our use of the computer as an audit tool has proved to be successful. In the very near future, we will be using our program as a normal audit procedure on all our stockbrokerage clients who have computers. In addition to its current and future audit benefits, we foresee other uses of our experience and capabilities.

We hope to use the computer on certain phases of the audit of clients who do not have computers. Clients' card files would be converted to tape and the tape records would be run through our audit programs. Computer time would be rented from service bureaus, other computer users, or might serve as a factor for justifying our own computer installation which would be available for use on audits. We feel we can use the computer to effect cost savings on unit record audits.

Many of the programs we have developed would be of significant value to any of our clients involved in developing and implementing a computer system. Our efforts have done much to increase our own sophistication in the computer area and this experience will be of great value to many smaller clients. In some cases, clients will be able to use our programs virtually intact.

At present, our programs are oriented toward one particular computer.

However, by using compiler and simulator programs (many manufacturers have developed special programs which convert programs from one language to another; these translations minimize the need for reprograming when changing from one computer to another of a different type), we can generate a program which will run on almost any major computer. When COBOL becomes more generally standardized, we will give serious consideration to the conversion of all our programs to this universal language.

Our experience with the computer and its audit applications has been rewarding in many ways. We have learned many valuable lessons which will benefit both ourselves and our clients. At the same time, we have faced the challenge presented by the computer and have added it to our list of audit tools. As we make further use of the computer and its techniques, we will be able to increase the value and range of the services we may offer to our clients.

M. J. GROSS JR., CPA

Computer Assists Inventory Check

A MANUFACTURING COMPANY has several plants in the United States which produce a number of large, complex devices. One of its plants, with several thousand employees, has approximately thirty thousand parts in inventory. These parts are kept on hand at all times in sufficient quantities to meet production requirements. Some of them are manufactured by the company at this plant, some transferred from other plants, and the rest purchased from other companies. Most parts are physically very small, but a few are quite large and represent major assemblies. The parts inventory is in excess of $20 million. In addition, the company has a large inventory of work-in-process.

A perpetual inventory record of quantities and dollar amounts of each part on hand is maintained on magnetic tape. This perpetual inventory is relieved when a part goes into work-in-process. The inventory record is used continuously by the production control department in maintaining adequate quantities of parts on hand and in reordering or arranging for production of parts which fall below minimum requirements. It is also used for financial and accounting control.

A general ledger account is maintained for work-in-process but a perpetual quantity record for such individual items in process is not kept. Therefore, the company takes an annual physical inventory of its work-in-process in the latter part of the year. The general ledger is adjusted at that time for any differences that may result.

As a part of our audit, we observe and test the perpetual inventory of parts during the course of the year, and we observe and test the annual work-in-process physical inventory. The case study discusses how we have used a computer to assist us in each of these two separate inventories.

Perpetual inventory of parts

Testing the quantities. As our test of the quantities in the perpetual inventory of parts, we selected on a statistically random basis a number of parts from the inventory. Our universe was determined from a priced listing of the perpetual inventory as of a recent month end, which we agreed with the general ledger. This complete listing was stratified by the company as to high and low dollar value parts. Our selection was also stratified in that we selected about half of our sample from the approximately 3,000 high dollar value parts which represented approximately 50 per cent of the dollar value of the inventory. In addition, we selected and counted a number of parts on the floor and traced these counts into the perpetual records.

The company has rotating count teams, which make inventory counts and adjust the records on a continuing basis throughout the year. During the course of the year all parts are counted at least once. We observed the work of the rotating count teams and reviewed the results of their counts and investigations.

Our use of the company's computer was in comparing our counts to those on the perpetual inventory record and in summarizing the results. If the perpetual inventory had been in punched card form or in some written format, the use of a computer would not have been necessary. However, this record was on tape and a computer had to be used to make the comparison. Our input consisted of the part number and the quantity counted. We received as output a tabulation showing: (1) part number; (2) our count; (3) the perpetual inventory quantity; (4) the quantity difference (3−2); (5) unit cost; (6) dollar amount of the variance; (7) per cent variance (4÷3).

In addition, this tabulation was summarized as to the aggregate dollar amount of the variances in excess of book amounts and the aggregate dollar amount of the variances less than book amounts.

We were able to rely on this tabulation because we obtained a priced listing of the complete perpetual inventory of parts as of the month end before our inventory count. We compared the quantities shown on the tabulation of our test counts obtained above with the quantities shown in the complete listing of the perpetual inventory. If there were significant changes, we investigated them. In addition, we submitted altered quantity data to the company for comparison with the perpetual inventory tape to note if a variance appeared. This variance was then manually excluded from the totals described in the previous paragraph.

Problem of cutoff. Our major problem with cutoff was to assure ourselves that we compared our count to the perpetual record at the proper time. The company was on a two-day processing cycle. For example, all stock receipts and withdrawals for Monday and Tuesday were processed on Wednesday night and we compared our counts to the perpetual record after this processing. It was necessary for us to stop the processing of all documents pertaining to all receipts and withdrawals taking place between the time of our count and the time we made our comparison. Where we found we had a physical difference between our count and the perpetual record, we recounted the part and where necessary we reconstructed the quantity on hand at the time of our count. We also reviewed the company's internal control over receipts and withdrawals and satisfied ourselves by physical observation that the two-day cycle referred to above was being followed.

Test of pricing. As our test of pricing the perpetual inventory of parts, we compared this perpetual inventory record as of a month end to a "master" cost tape which contained the costs of all parts, assemblies, and completed devices. This tape was an historical record in which cost information was accumulated for all parts, assemblies, and completed devices. This record was tested as described below. By comparing costs as shown on this cost tape to the perpetual inventory record, we established an audit trail from the source documents to the inventory. This comparison was performed on the company's EDP equipment. We received an "exception report" tabulation which listed those parts for which prices did not agree with the "master" cost tape, and we followed up all exceptions. We were able to rely on this comparison because we received a copy of the perpetual inventory and compared manually on a test basis the prices thereon to the "master" cost tape in print-out form to ascertain that the "exception report" was correctly prepared.

We tested the "master" cost tape in considerable detail, by means of an entirely separate audit program for this work. Basically, for purchased parts, we tested prices to vendors' invoices and interplant invoices for shipments from other plants. For parts manufactured in the plant, we examined the cost records showing the compilation of labor, burden and raw materials cost for each part and tested to applicable source documents. Our tests of payroll and cash disbursements were directly coordinated with this cost program.

Testing clerical accuracy. We checked the clerical accuracy of the complete inventory listing by having a Comptometer operator test extensions and footings.

A wall-to-wall physical count. The company's annual inventory of work-in-process assemblies involves a complete wall-to-wall physical count which took approximately one thousand persons about six hours of actual counting. Approximately 100,000 individual count cards were used which were controlled and accounted for by the accounting department. These count cards were numbered and the serial numbers prepunched in them. We had about fifteen men observing the inventory and in total they recorded about seven hundred counts for subsequent tracing into the final priced inventory. The test counts were more than might be required if statistical sampling methods were used. However, establishing the universe and making a random selection would have been extremely difficult during the inventory taking. Accordingly, counts were made on a judgment basis by the staff members observing the physical inventory. They also recorded serial numbers of unused cards returned by each department. The company prepared and gave us at the completion of the actual count a listing of the serial numbers of all unused inventory cards, which were checked by us against the card control we recorded following the counting process at the various departments.

The company's final priced inventory listing included all 100,000 individual count cards but their listing was in department number order, and then within departments the count cards were in part number sequence. There were over one hundred departments. Consequently, the time necessary to manually trace our seven hundred counts into the final inventory run would have been quite high. Furthermore, it would have been very difficult to search the company's final inventory listing for count card serial numbers of cards that were not used during the observation because the 100,000 count cards were not in serial number order.

Our computer program. Accordingly, we had the company prepare a program which performed the following steps:

1. Transferred the complete inventory from punched card form onto tape.

2. Sorted the inventory to count card sequence.

3. Compared our seven hundred counts to the inventory in count card sequence. Prepared an exception list of all differences.

4. Searched the complete inventory for serial numbers of all unused

count cards to determine if they appeared in the inventory. Prepared a list of all serial numbers that did appear which we then investigated. (These serial numbers turned out to be unused cards which were later used in place of count cards that were bent or mutilated.)

5. Printed out the complete inventory in count card serial number sequence, with subtotals printed every one hundred unit records.

Once this program had been run, our work was limited to (1) analyzing the results and following up on exceptions, and (2) satisfying ourselves that the program had been run as we had requested.

Problems of cutoff. We obtained abstracts of receiving reports for several days before and after the inventory date and we traced these through appropriate summaries into the records to ascertain that a proper cutoff had been effected for the inventory count. In addition, we physically observed all plant areas for movement of materials during the inventory count.

Most of the shipments from the plant involved large assemblies going to customers or small assemblies going to other plants. We observed and recorded selected shipments before and after the inventory, and we recorded shipping data on shipments to other plants for subsequent confirmation with our staff at these plants. Because of the large size of the parts being shipped, we had no difficulty in establishing control over movements.

Tests of pricing the inventory. As with the perpetual inventory of parts, we had the company's EDP equipment compare the prices used in the work-in-process inventory to the "master" cost tape at the inventory date. As with our comparison of the "master" cost tape with the perpetual inventory of parts discussed above, we obtained an "exception report" of prices that did not agree and we followed them up.

Also, we compared costs on this "master" cost tape with the tape in effect two months before the inventory date to guard against unauthorized changes of cost records at the inventory date. Obviously, with over thirty thousand parts, the unit cost on many parts changed during this period. Therefore, as a mechanical means of eliminating cost changes which were not significant to our audit, the program was written so that an "exception report" was prepared, which contained only cost changes of more than 10 per cent which when extended by the inventory quantity resulted in a dollar variation of more than $1,000. This program was very effective in ascertaining that the "master" cost tape had not been changed for purposes of pricing the work-in-process inventory. This program was also effective in disclosing significant cost variances between the "master" cost tape date and the physical inventory date.

As noted above, our accounts payable and payroll work were integrated into a comprehensive cost program designed to test the "master" cost tape.

Test of clerical accuracy. We had a Comptometer operator check price extensions and footings. As noted above, the final work-in-process inventory was printed with subtotals every one hundred unit records to facilitate the test footing of the inventory.

Summary of our use of the computer

As discussed above, we used the company's electronic data processing equipment for the following purposes:

1. To obtain a complete, stratified listing of the perpetual inventory of parts;

2. To compare our counts of parts to the perpetual inventory of parts, and to summarize the results thereof;

3. To compare all prices used in the perpetual inventory of parts to the "master" cost tape, which we tested;

4. To obtain a complete listing of the work-in-process physical inventory in a format which facilitated our use of it;

5. To compare our physical counts to the final inventory of work-in-process;

6. To search the final work-in-process inventory for serial numbers of presumably unused count cards;

7. To compare the prices used in the final inventory of work-in-process with the current "master" cost tape;

8. To compare the "master" cost tape used to price the inventory with the "master" cost tape in effect a couple of months earlier.

Our audit controls over the computer

In the use of these programs we relied on a number of controls to assure us that the company processed our data as we requested it to be processed. These controls were principally the following:

1. We included altered or controlled data with the data we had the client process for us, to see if it were properly handled.

2. We obtained complete listings of the work-in-process and the perpetual inventory of parts before giving the client the specific information regarding our test counts to process.

3. We relied on the complete separation of the computer processing department from the financial and production departments.

4. We tested some of the data manually and compared the results with those produced by the company's EDP equipment.

5. We withheld from the company the specific part numbers counted until immediately prior to the scheduled processing time.

We found these controls to be quite effective and did not feel it was necessary to have one of our MAS systems specialists present during the actual processing.

Preparation of our programs. Our client readily recognized the need for and desirability of our using their EDP equipment for audit purposes. It was evident that the manner in which they processed and stored their inventory records made some use of this equipment necessary. They also recognized the advantage and cost savings in using their equipment for performing audit tests which would otherwise have had to be done manually.

The plant controller arranged for one of their programers to prepare and initially test our programs. Thereafter, we dealt on a very close basis with the manager of the data processing department. Since he had several programers on his own staff, minor modifications of our basic programs were handled by him. We had no difficulty in having these programs prepared once we had outlined completely what we wanted. We did not have our programs reviewed by our MAS department but relied on the controls noted above.

Computer time requirements. The company advised us that the computer processing costs for all of our programs were less than $2,000, and that it took about one hundred hours of programing time. It is somewhat difficult to estimate the savings in audit time resulting from this processing because in several of our programs we performed steps which for all practical purposes we could not have done effectively otherwise. An example of this was our complete search of the entire work-in-process inventory for the serial numbers of presumably unused count cards. We estimated, however, that these programs have reduced our audit time by two hundred hours, while at the same time making it possible to perform more effective tests and to concentrate on following up exceptions.

Programing problems encountered. The need for carefully prepared programs and the necessity for constantly reviewing them for applicability are shown in two situations we encountered:

In the first year that we ran our work-in-process program, we neglected to instruct the computer what should be done if one of our test counts could not be located in the final inventory. Not having instructed it to prepare an exception listing, the computer, of course, did nothing. We became aware of this omission in following up altered data which we submitted to make sure the program was doing what we wanted.

The third year we ran our perpetual parts inventory interrogation, we discovered that the company's perpetual parts inventory tape had been changed since the previous year in that the quantity on hand was now shown at two addresses which had to be added together to get the total quantity. In the first two years the total quantity was shown at one address. We discovered this change when we were following up differences, and our program was subsequently modified.

The benefits gained by utilizing the company's EDP equipment consisted not only of saving auditing time but also in being able to perform more effective tests and being able to concentrate on "audit by exception." In addition to these benefits, our own staff increased their knowledge of the nature, capacity and limitations of such equipment and found the audit far more challenging.

FRANZ E. ROSS, CPA

Internal Control and Audit of Real Time Digital Systems

THERE ARE currently a few score real time digital systems in operation, but hundreds more are planned and on order for installation during the next few years. While the average CPA is not likely to encounter a real time digital system at the present, many CPAs will be asked for counsel and guidance in the planning and installation of such systems during the next few years. Moreover, it is not unlikely that in the foreseeable future some of the key economic functions of our society may be accomplished by real time digital systems. Thus, it behooves the CPA to acquaint himself with the special problems of control and audit of such systems and to look at some of the possible solutions.

A real time digital system may be defined as one or more digital computers and other devices used to participate in, control or monitor a business, industrial or scientific process while this process is actually taking place. In other words, the computer, input/output units and other devices have become part of a live process. The digital system must be ready with its results when they are needed for the process, and must be available for new transactions as they occur.

Typical examples are real time demand deposit systems, production control systems, and various control, warning and communications-switching systems in the area of national defense. The spread and status of real time systems in various industries are described in chapter 2, p. 22, "On Line-Real Time Systems—1964," Richard E. Sprague.

Basically, such real time systems have this one characteristic in common: transactions or intermediate stages in a process are flashed—as they occur—to a central computer installation for processing or recording, through a terminal or sensors or some other input device. This is often done via a communications network. At the central computer site is a device which handles many input sources that simultaneously try to obtain the attention of the computer. It assembles the input messages and feeds them to the computer in an orderly fashion. The computer then processes these messages. It may obtain results and feed them back to the live process so as to influence its subsequent course, or it may update information stored in the files so that the stored data represent up-to-the-minute complete and correct information available for inquiry. The system has to be capable of processing the input within the time allowed, as the penalties of not keeping pace may range from loss of revenues, in business systems, to wholesale disaster and death, in such defense systems as BMEWS (Ballistic Missile Early Warning System).

Thus, a typical real time system includes, but is not limited to, terminals or other input/output devices, a communications control unit or real time channel, a processor, and, almost invariably, large, random-access files or auxiliary storage. Recent equipment developments have emphasized designs oriented to carry out real time functions, and have greatly simplified the systems design, preparation for, and implementation of, real time digital systems.

The majority of real time digital systems will consist of small- and medium-sized systems which process transactions sequentially, in the order of input, without pre-emption of system facilities by priority transactions. However, regardless of size and complexity, these systems are characterized by at least some of the following features:

(1) Short reaction time. Participation in or control or monitoring of the live process is effected by a series of individual transactions, measurements or status reports which are brought into the real time system for processing. Response to each event, such as a savings account status inquiry, usually has to be within seconds. In industrial process control or scientific or national defense real time systems, measurements may not require individual response, but critical data must be selected and analyzed and appropriate action taken within a few thousandths of a second. Thus, in almost all real time computer systems, economy of time is a prime consideration in design.

(2) Peaks and queueing. In many real time systems it is well known that a fairly high percentage of the periodical transactions occurs over

a relatively short, predictable span of time—the peak period. Moreover, at any time, due to simultaneous input from many parts of the system, a temporary and random peak can occur. The system must be so planned that it can handle such peak loads in acceptable time. Queues of transactions and output messages result from input from various sources vying simultaneously for central processor attention and from output waiting to be moved out of the system. Therefore, there must be some prearranged priorities or some general rules such as first in, first out.

(3) Heterogeneous input. In most real time applications, different types of transactions flow through the system, each of which has to be processed according to different rules. In an on-line savings system, for instance, deposits, withdrawals, mortgage payments and Christmas Club payments would each be processed by a separate transaction routine. In view of the usually tight schedule, it is, of course, desirable to have as many of the frequently used program routines as possible held in the main computer storage: bringing in routines from auxiliary storage as they are needed is usually time-consuming.

(4) Control program. Owing to the tight time schedule and the resultant priorities, it may be necessary for the data processing equipment to process different sets of data with different program routines at the same time. These routines may have to be brought into main memory from auxiliary storage. Many operating decisions must be made; e.g., whether to move output into some communications lines or free them for accepting input. The schedules of data to be processed, program routines to be used, and operating decisions necessary are made by the supervisory or control program, which links up the individual program routines to be used under the changing conditions. This control program also deals with the interaction among program routines which use the same account balances, constants, machine registers, etc.

Thus, in a system with priority transactions, the control program may move a set of data into the system, which processes it until receipt of data of higher priority requires interruption. The earlier data and the partially completed program routine may then remain in memory (or even be temporarily moved out to auxiliary storage) until the high-priority items have been dispatched and control is returned to the partially run program for completion of processing. In such a case the sequence of instructions actually carried out by the equipment can be determined only if all inputs received and their relative timings are exactly known. It thus does not necessarily follow that two transactions of the same category will always be processed in the same manner in a real time system.

(5) Continuity of operation. One of the prime differences between a real time system and a system processing historical data is that the real time system must be available for processing whenever transactions occur. This availability is accomplished mainly through the reliability of the equipment and through careful systems design, which relies on back-up equipment or back-up procedures when the equipment is inoperable.

(a) Reliability of the equipment. This is a subject which, because of defense and space projects, has received considerable popular attention. For clarification, the main principles are these: The realiability measurements which are significant to the user of an electronic data processing machine are the average time the machine will stay in operation until it breaks down (mean time to failure), and the average time for repair from the time of breakdown until it is again fully operable (mean time to repair). If these measurements are known for individual machines, the measurements for a system can be obtained by calculation or simulation.

Although these measures sound quite simple, they are very complicated and have many ramifications which are not obvious; thus, for the layman, they are practically impossible to evaluate and to compare.

At the present time, there are no recognized industry-wide standards for computing these reliability measures. Thus, for instance, a manufacturer may or may not include preventive maintenance time in the mean time to failure, or he may or may not include diagnosing the failure and/or final checkout after repair in the mean time to repair.

Another problem is that these measures are defined in terms of operability and breakdown, but in real life things are not always so clear-cut: The electronic equipment may not just break down; its operation may become interlaced with more and more frequent errors, which, although they may be detected by hardware and systems checks, slowly bog down operations. The point at which the user throws up his hands in despair and requests unscheduled maintenance depends on the nature of the use of the equipment and on the temperament of the user. Thus, the basis of these measures—the point in time when the equipment actually fails and requires unscheduled maintenance—is often not exactly determinable.

Moreover, these reliability measures are far more encompassing than measurements which merely calibrate hardware performance: They measure also how close the points of service (where maintenance engineers are available) are to the customer locations, the quality of equipment servicing, and various aspects of systems design and programing. For instance, it is obvious that the quality of preventive maintenance will strongly influence how long the equipment remains operable before breakdown, and that the availability of spare parts and the training of maintenance engineers are contributing factors to the speed of effecting equipment repairs.

(b) Back-up equipment and procedures. In order that the real time system survives to accomplish its intended function even after one or several critical machines have failed, intelligent system designers will consider the backing up of critical pieces of equipment with other hardware capable of carrying out the same functions. The alternative to backing up one or more operating machines with stand-by, functionally similar units is to fall back upon some devices with lower capability or a configuration which cannot handle a peak transaction rate without delays, or to eliminate or defer certain less essential functions, or to carry them out by nonautomatic methods. All these methods of doing something less than the total job in the case of equipment failure are referred to as degraded modes of operation.

The purpose of all these techniques is, of course, to design a system which can somehow continue its most essential functions under all but the rarest and most improbable catastrophic failures. To what extent this purpose is being accomplished can be realistically measured by comparing the exposure to, and effects of, equipment failure, or other possible causes of systems interruption, of the automatic real time system and of the prior manual or semiautomatic system.

The resultant system is a complex of machines with various stand-by units, switch-over devices, and a highly organized set of emergency techniques and fall-back procedures. Thus a real time digital system often requires custom-built connections and special devices.

(6) Systems integration, testing, and implementation. If the real time system is not a standard configuration, considerable testing of the interconnections and relative timings by the manufacturer, known as "systems integration," is necessary prior to installation. The final checkout of the equipment really occurs, however, during the testing of the real time programs.

Program testing of a real time programing system is lengthy and complicated: A real time system cannot afford to have "bugs" or errors once it is put into operation, for such program or machine errors could shut down the system or create useless or, what is sometimes worse, misleading output. On the other hand, to completely test out all paths in a real time program is, timewise, often impossible. It has been estimated that a certain airline reservations real time system contains 250,000,000 possible paths through which an input may pass to produce a response. Thus, test data have to be well chosen to test out the system without causing undue delay. Special machine programs may have to be written to assist with the testing and implementation (putting into operation) of the real time system. All programs need testing.

Implementation of the real time system and program testing in the real time environment are carried on simultaneously. Implementation, however, also requires organization of many other matters without which the system cannot properly perform: co-ordination of servicing arrangements with communications common carriers and equipment manufacturers, training of all operating personnel, availability of needed supplies, planning and testing of emergency procedures, and many others. Failure to complete necessary preparations may delay cutover significantly.

(7) Off-line processing. In most real time systems, a large part of all processing is still devoted to batch processing, which usually amounts to an after-the-fact processing of historical data. This batch or other off-line processing requirement is due to other, non-real time, applications being run on the same system, and to the many non-real time functions such as file maintenance runs, reconcilation of detail and control, and others which are essential to keep the real time system in operation.

Techniques of control and audit

It is essential that there exist a group organizationally separate from the computer installation—a group which is knowledgeable about EDP and understands the operation of the real time system. Its members should independently monitor the operation of the system and verify that the system is efficiently used and adequately controlled and that the planned controls are actually in operation. This need goes deeper than the normal requirement of organizational independence of control and audit personnel: No group within a business should have a monopoly on some specialized knowledge which would enable them to avoid supervision and restraint.

The real time system makes transaction detail and summary information centrally available on a current basis for computer analysis. This capability means that the "control by exception" technique can be broadened to a management review of exceptional transactions in time to intervene, and not merely after the fact. It also implies use of the computer as the main tool of control rather than imposition of extraneous controls, which might make it impossible to keep up with real time events.

There have been several years of argument as to how much the auditor has to know about EDP. This problem has really been a "front" for a deeper and more serious problem: Should the auditor audit the total EDP system or should he "audit around it" by just examining and correlating the original input and final output of the system? There will be real time systems where it is no longer possible to match inputs and outputs and where an auditable sample of correctly processed transactions does not constitute full assurance that under the many possible sets of conditions the same transactions will always be correctly processed. Thus, the only way the auditor can gain the necessary confidence in the operation of the system and its results is by having a basic understanding of how the system operates, how results are produced, and what controls and other safeguards have been instituted and are actually utilized.

The problem of audit trail is no different in a real time system than in any other EDP system which has large-scale random-access storage and has, thus, the capability of processing transactions in the order of occurrence rather than by batch. This problem and its solutions have been very adequately described elsewhere. It is important, however, that the auditor make his needs known, particularly for audit trail information, at an early stage in systems planning. Otherwise, changes in systems design and programing become difficult and time consuming, and thus expensive, in view of the critical timings and scarcity of quick-access storage usually encountered in a real time system.

Upon the first review of a real time installation, the auditor may wish to satisfy himself that the system is adequate for its purpose even during seasonal peaks or, alternatively, that arrangements can be made to handle the expected transaction volume when it exceeds the capacity of the system. Similarly, the auditor should examine the emergency measures which exist for handling the real time process in case of some calamity such as fire, long-term electrical outage, or catastrophic equipment failure. It is noted that unless such emergency measures have actually been tested under operating conditions, they cannot be relied upon to function when needed. Such a review of the adequacy of the real time system and the emergency planning is considered necessary, as failure in either of these areas may cause unanticipated losses.

The most important single control available to the auditor for checking on the total system is the processing of test transactions through the system. These test data should be prepared by the auditor to check on the operation of input, processing, and output controls and therefore should include incorrect, incongruous and inconsistent data and data deliberately designed to "beat" the controls. The program may recognize test data by a certain code and refrain from adding them to results, statistics or permanent records. If the program has this capability, it is possible to mingle test data with actual transactions.

Apart from test transactions which check the functioning of the equipment as well as programing and operation, it is easiest to tackle the problem of audit and control of a real time digital system, or any other EDP system, by examining the separate functions of input, processing and output.

Input

There are two basic types of input in a real time system:

1. **Transaction input.** These are the transactions, status reports, measurements, or other evidences of change which pass from the live process to the real time system. They are the stimuli to which the real time system reacts.
2. **Master record and constant input.** These are the types of data which remain permanently either in quick access storage or in bulk storage of the real time system. These may be subject to continuing change as a result of the real time transaction input, as in the case of the master file, or may be unaffected by the real time process and separately updated when needed, as in the case of constants, rate tables, and programs.

Transaction input. In a real time system, the transaction input poses two main problems of control: (1) It may not be evidenced by independent input data in machine-sensible form which can be separately controlled and audited, and (2) it may be almost impossible to substantiate in which order the transactions from the various input sources are presented to the real time system and processed by it. Both difficulties are eased or almost eliminated by keeping a transaction log in the real time system.

This log consists of all transactions accepted by the real time system, usually in the order of acceptance, including any errors made at the introduction of this data into the system, and contains all detail necessary for complete reprocessing of the transactions in case of loss of data or equipment failure. The transaction log, together with a recent set of master records, also makes possible re-creation or verification of the up-to-date master records. Individual transactions contained in the transaction log can be sorted, by master record, into a daily transaction journal so that, say, last night's master record balance plus today's transactions will verify tonight's balance of the master record. Similarly, the transaction log can be summarized by the type of transaction to confirm the summary information in the control accounts. The daily transaction journal can also be merged into a cumulative transaction journal to show all transactions affecting the individual master record for the month, the quarter, the year, as may be necessary. For these various control purposes, the transaction log is written from time to time into some storage medium outside the real time system.

In order to have the fullest and most effective use of the log as a backup device for accounting controls and for subsequent audit, it is usually desirable that the log be posted as the transaction enters the real time system, and that during processing the master record as well as summary or control records be posted with each individual transaction. As a safeguard against equipment failure, the master records and the pertaining transaction log should be stored, when feasible, in functionally separate storage devices, so that the probability of losing both sets of data simultaneously becomes nil for all practical purposes.

If there is adequate checking from the input device through the central processor in which the log is created, it can be assumed that the log will contain the same information which was introduced into the system. Thus, the log is usually no worse but certainly no better than the original input. It is, therefore, essential that audit procedures be instituted to assure that all data entered represent correctly the actual transaction, and that no transaction has been completely overlooked.

Two methods are open to control the accuracy of transaction data entered. One is the use of data which may be available outside the system, in other departments of the company or from other outside sources. The other method is to use the processing power of the system for as complete a check as the limited time will allow—for consistency, reasonableness and statistical creditability of the data introduced.

Even cursory analysis will show that the problem of overlooking a complete transaction is not as formidable as one might first suppose. Any system where the transaction is introduced into the system as it occurs, by automatic means and without human intervention, or where the transaction input is only a small sample selected from a larger number of data can be ruled out. In the first type of system, proper machine maintenance will assure that no transaction is omitted; in the second type, the individual transaction, usually a measurement, is not significant, only the trend which the measurements establish. Both these presumptions must, of course, be confirmed by audit. The type of system which is most vulnerable in this respect is one in which a separate, deliberate action by an operator is a prerequisite for introduction of a transaction into the system. But even in those systems, complete skipping of a transaction is not likely, for often some inquiry for information contained in bulk storage precedes the transaction.

Depending upon the system, many ingenious methods can be designed to minimize the chances of the omission of a complete transaction and to ascertain afterwards whether any transactions have in fact been missed. Based on the principle that very little happens without leaving an ascertainable trace, evidence will be available if transactions have not been entered, particularly if such omissions tend to occur frequently. For example, missed receipts or issues from an inventory result in differences between the real time inventory and warehouse contents. Thus, even in the absence of auditable independent records outside the system, the ingenuity of the auditor will enable him to substantiate how reliable the transaction log really is.

If in some system independent auditable input records are provided for all transactions, the well-known techniques of input control such as control totals, batch controls, serial numbers, hash totals, checks on the reasonableness and validity of data input, etc., can, of course, be used. Some of these controls will even be applicable in cases where independent input documents are not always provided. For instance, in an intra-company real time message communications system, it is usually desirable to sequentially number the messages originated at each terminal.

When input originates, as it normally does, at various individual input terminals, it is possible to tag every transaction record with the identification of the input terminal used. Thus, the transaction input can be analyzed and audited according to the originating terminal. As a consequence the auditor could observe one individual input terminal and subsequently audit the systems operation as far as the input from that individual terminal is concerned.

The most important new element in a real time system is, of course, time itself. If the system includes an electronic clock, it is possible to time-tag every transaction with the time at which it was accepted by the system. An alternative which is less time and storage space consuming, but only possible in strictly sequential logging, would be to time-tag every fifth, tenth, fiftieth, or other nth transaction, or to write a time record periodically, say every minute, into the master log. It would then be known that all transactions logged between two subsequent time tags or records were received within the same period. If time is thus used as an element of control and audit, it becomes possible to survey the efficiency of operations of the real time system after the fact, to make meaningful audits of the total operation of the system, notwithstanding the great amount of detail involved by isolating a sufficiently short time span. Such investigations, of course, can become even more meaningful if the output is similarly time-tagged.

In a batch-processing system, transactions covering a relatively long period of time are processed together. It quite frequently occurs, therefore, that we encounter cancellations before the orders, issues of material from inventory before its receipt, and similar incongruities. In a real time system, such occurrences should be investigated, as they may be indications of improper operations of the system or of irregularities.

One of the main objections raised against reliance on the transaction log is that it is completely and consistently under the control of computer room personnel. This fact, of course, accentuates the importance of such independent input records as may exist in other departments, and of the audit and control procedures carried on to verify the dependability, accuracy and completeness of the master log. It is necessary, therefore, that any such independent input records and/or audit verification of the master log should not be under the control of any person directly connected with central real time systems operations. Similarly, computer personnel should have no access to terminals which have the capability of originating transaction input. Thus, it is desirable that the control console or other terminal under control of computer room personnel not to be used to originate or modify input. The computer can be used to verify the fact that input originates only at terminal stations intended for that purpose.

Master record and constant input. To guard against loss of data, equipment failure, and for purposes of control and audit, it is absolutely necessary that master records be extracted from the system periodically and stored outside at a location resistant to fire, flood, and other hazards. Contents of the master file can be "dumped" in one operation onto magnetic tape, cards, or other machine-sensible media. In addition, for customer inquiry and other purposes, it is usually necessary to print out the master file from time to time. Another method is to write out the master file on a cyclical basis, each day some part, so that in a complete cycle, say a week, the complete master file has been extracted and the cycle can start all over again. One refinement is to classify the records of the master file according to frequency of usage or criticality of the item. (Criticality here may mean value of an item of inventory or its attractiveness to pilferers, or the importance of a customer.) In this case, extracting and controlling the more often used and more sensitive master records on a more frequent schedule than the remainder of the master file would result in a more economical use of systems time and media.

It is also necessary periodically to dump the control and summary accounts from the system. Thus, there is stored outside the system a recent copy of the master file, a recent set of summary and control accounts, and the transaction log accumulated to a recent date. In addition, these same types of data are available within the system in up-to-the-minute form. This information makes possible most normal accounting checks and allows reconstitution of at least the most essential data if any of these files are lost.

It is also necessary to write out from the system price lists, rate tables and other constants on a periodical and surprise basis. These constants should then be checked against approved data maintained outside the system. For instance, in the case of the rate table of a utility, incorrect rates would cause a tremendous number of incorrect invoices and, hence, complaints. Therefore, all changes in the constants and tables maintained inside the real time system should be made only in accordance with a regularized procedure, including written approvals and a printed and a machine-sensible change register. Such methods will facilitate subsequent audit verification both by scanning and automatic methods. It is, of course, important to store outside the system sufficient historical constants so that, upon a later audit or outside inquiry, results obtained during the earlier period can be substantiated on the basis of prices, rates, or other constants then used. The same regularized change procedures, written approvals and periodic verification should also be applied to the computer program as will be described in more detail below.

One last observation on input: No results can be any better or more accurate than the input from which they were generated, or in the language of computer personnel "garbage in, garbage out" (Gigo).

Processing

Based on satisfactory input, if the *equipment* is in good operating condition; if the *programs* are well designed for the intended purpose, properly controlled, and tested out; and if there is no *unauthorized intervention* in the operation of the system, satisfactory results should be obtained.

Equipment. Normally, and unless there is information to the contrary, the auditor will assume that the equipment is properly designed, carefully produced, and capable of satisfactory performance. He should, however, make it his business to know enough about the individual pieces of equipment to understand the capabilities and weaknesses of the system. Otherwise, his control and audit procedures may not correspond to actual requirements: For instance, if in a real time system all equipment and data links contain adequate and reliable checks, built in by the manufacturer, except the lines to the output terminals, then obviously the most elaborate systems controls should be applied to the output data transfer, together with incisive audit procedures to verify that these control procedures are actually being utilized and are adequate for the purpose.

Electrical, electronic or mechanical equipment does not perform satisfactorily forever; it must be properly maintained. In order to rely on equipment performance, the auditor should satisfy himself that dependable maintenance arrangements exist. In the case of equipment leased from a reputable manufacturer, maintenance service is provided as part of the leasing contract for the equipment, which continues to be owned by the manufacturer. Similarly, adequate maintenance of common carrier communications equipment and lines is furnished by the common carriers on their tariffed services. It may also be assumed, unless there is information to the contrary, that maintenance is likely to be satisfactory if a regular maintenance agreement exists with an equipment manufacturer or a reputable service organization, or if the equipment is maintained by clients' employees who have been properly trained for this purpose and are regularly assigned to it. Equipment performance, however, is suspect if maintenance arrangements are haphazard and are only made in an extemporaneous and erratic manner when repairs can be put off no longer.

An appropriate source of information on equipment performance, in addition to observation and inquiry, is the operating log which usually is, and should be, kept with the equipment. This log should contain various items of operating and maintenance information such as hours of equipment usage, preventive maintenance, equipment failures, unscheduled maintenance, and names of personnel servicing the equipment. A well-kept log will enable the auditor to assess the condition of the equipment and to what extent he can rely upon proper performance. Clearly, during periods in which there is evidence of equipment malfunction, normal assumptions as to equipment performance cannot be made.

In order to be assured of proper functioning of the equipment while operations are actually carried on and to know when and where maintenance is needed, it is necessary to make arrangements for some or all of these or similar monitoring and testing techniques:

1. **Operating performance statistics.** Errors should be accumulated, by type of failure, for each terminal, communications line and other major systems component. Alarms, display or print-out should result if the error rate becomes excessive, and statistics should be printed out periodically.
2. **Test patterns.** It should be possible to originate test patterns at any input/output device to test the input/output device itself and its linkage to the central computer.
3. **Transaction test.** A test can be programed which allows origination of dummy transactions at any time at any transaction input point. These transactions should exercise all the parts of the total system and produce correct results without, however, affecting the processing results of operations. Thus, operating and maintenance personnel can check out at any time whether the system is producing useful results.

Programs. Programs for a real time system are often particularly exacting, lengthy and complex. Thus, even if he has knowledge of programing, the auditor will find it a very time consuming and uneconomical employment of his efforts to delve into the details of the program of a real time system. He should, however, satisfy himself that the programs have been prepared by qualified personnel, that they were properly planned and carefully prepared. To this end, he may review some of the documentation compiled during the planning and programing phase: the training activities and schedules, programing standards and conventions, time schedules, various levels of flow charts, decisions on programing languages to be used, and others.

This review should extend to the systems checking techniques incorporated in the programs. These systems checks are well known and standard and include, among others, such techniques as proof figures, reverse arithmetic, limit checks, accounting checks and check-point routines. The question should be asked whether all conditions which can possibly arise have been provided for. All input errors, combinations of errors, and out-of-the-way conditions, which, however unlikely, are objectively possible, will sooner or later befall. Thus, in such an eventuality, data causing the condition have to be either processed by some special subroutine or have to be ejected by the system for manual handling. If the auditor has had prior experience with the live process which has been converted to the real time system, he is particularly suited to review whether in fact the program caters to all possible contingencies.

Probably the most important aspect for the auditor to check in detail is the program testing the real time program has undergone. As indicated earlier, the final testing out of real time programs is a major undertaking which, in the case of a major system, may take weeks or even months, requires detailed preparation, and even construction of specialized programs that serve only as tools for the final program check-out. The auditor would wish here to review in detail the planning for the program check-out, the data used, and the results obtained. If experienced in the data and results of the process to be automated, he should have competent judgment as to the transaction data to be selected to test out the system. Even where the system is so extensive that test data must be generated by automatic means, he may be able to offer realistic advice as to the relative proportion of various types of test data to be used.

The auditor should be particularly interested in the result of parallel operations, which is the parallel processing of the live process by the real time system and by the prior manual or semiautomatic system. A comparison of the results of parallel operations by a special computer program will usually furnish an exhaustive study as to the significance of the change in system from an accounting point of view. Manual methods of comparison, although more pedestrian, will be adequate in some cases, except where the wealth of data to be compared precludes a dependable judgment. The auditor will investigate what action was taken by programing personnel in all cases in which the analysis of parallel operations disclosed a major discrepancy, as such differences may significantly affect the consistency of successive financial statements.

However well designed a program may be, in the long-term use, it is no better than the documentation which supports it. Thus, an examination of the real time system would certainly include a review of available programing documentation, such as flow charts, coding sheets with explanatory notes, program listings in programing and machine language, and adequate and clear operating instructions for the operators. It is desirable that at least one set of up-to-date programing documentation, including the program itself, be kept at a location where it is inaccessible to computer room personnel, so that it can be compared from time to time with program documentation and the program actually used by the operators. The reason for this control is that computer room personnel tend to make quick fixes to the program when some unusual program difficulty occurs. Although such an extemporaneous change during the running of the program may be necessary to maintain the system in operation, there is a danger that such hasty program changes may introduce new errors or invalidate controls programed into the system.

For dependable operation, it is necessary that every computer installation have a standard method for effecting program modifications. Such changes should be supported by a document explaining the reasons for the program modification sought, the exact nature of the change, any incidental effects, and should be approved in writing by responsible personnel. If a change was originally made under the pressure of a real time system in operation, it should be subsequently approved in the same formal manner. Programs which have been used at any time productively, i.e., to obtain results used in the business, should not be completely discarded. One copy of every program used and of any appertaining program change documentation should be stored in case substantiation of the operating results obtained becomes necessary.

In order to maintain a real time system in operation even during equipment failure, stand-by equipment or fall-back procedures may be provided which will result in many cases in an anomalous mode of operation. It is, of course, necessary to design programs and procedures for such a mode of operation and, in particular, to prepare adequate controls for such a contingency. These controls must include a quick but thorough checkout of the newly constituted system when the fall-back mode is entered, and should generally be at least as extensive as the regular controls, for operating personnel as well as other users are unaccustomed to working with the changed system.

Unauthorized intervention. Due to the very complexity of a real time system, its control program, its operating programs, and the interaction between them, the likelihood that an operator or other company personnel would change the program or other operation of the system to achieve some improper purpose is small. It is also unlikely that an operator, in order to lighten his work load, could effectively circumvent the controls programed into the system if there is adequate supervision of computer operations. To guard against such intervention, it is possible to have the console typewriter print out any manual intervention into the system other than routine introduction of input through the input/output devices programed to receive them. The information so printed could be kept visible but under lock and key so as to be inaccessible except to control personnel. Alternatively, a "receive only" typewriter could be remotely located, say, in the office of a responsible executive, and be programed to issue periodically important operating information such as volume of transactions and total amount of money on deposit in a savings system, and to record automatically any intervention in the operation of the system.

The many different types of real time systems will also produce many different types of output. Techniques of control and audit of output will vary considerably with the quantity of output produced in a system. Thus, if the only output of a system is answers to inquiries as to status of individual master records or summary accounts, the main output controls needed will be those to assure the correct transfer of data and the security of confidential information. Thus, the program would assure that only output terminals cleared for confidential data could receive them.

If the system produces quantity output, some of the output controls applicable to a batch-processing system will be utilized; thus, output documents may be under numerical or batch control or be subject to some other standard internal control procedure. Exception reports of unusual transactions or abnormal results may be prepared by the system for review by appropriate personnel. Special computer programs can be prepared to sample input, compute the output, and verify that such output, in fact, was created. Conversely, other special programs may sample the output, deduce from the output sample the types of input which could have created it, and verify that, in fact, such input data were introduced into the system. In general, it is always possible to make a statistical review of transactions and results by using the processor to compare them to the equivalent data of the preceding period.

If possible, it is desirable to compare operating results with independent outside data such as physical inventories and positive confirmations of accounts receivable or payable. Differences can then be analyzed by computer and should be investigated in detail, as the early availability of the results through the use of a real time system makes it possible to find the cause of the differences and to prevent further irregularity, if any.

It may be desirable to permanently record all types of output created. For instance, if the output is merely a display of certain digital information, it is useful to write the information displayed on a permanent medium so that it will be available subsequently to substantiate what data were displayed and for audit.

In some systems, particularly where the amount of output created is large, and where input and output do not match up or are not received by the system in the same order in which they are dispatched from it, an output log may be an effective tool of control. The output log will contain identification of the output record and its salient data and results, sufficient to allow subsequent verification that output data were correct and to recreate transaction input or master file information in case of loss of data or machine failure. Various types of controls can be tied in with the existence of an output log. For instance, in a message communications system the messages received at the switching center (input) less the messages dispatched (output) should equal the number of messages in storage at the time of the control procedure.

Another effective way of using the capability of the real time system for control is by means of the feedback principle. This principle signifies generally that every change in a process is followed by a response which may act to modify the process; examples are a thermostat or the automatic choke of a car. In a real time system it implies that, after a transaction occurs, the system returns a positive response to the transaction source, which may influence subsequent transactions. For instance, upon entry of an order a message could be returned that the order has been accepted or, alternatively, that orders for those goods can only be entered for sixty days' delivery. Such a response would furnish a clear-cut commitment and would create an auditable record of systems output.

There is, of course, one factor of prime importance: personnel who have worked on transaction input or on the operation of the real time system should not be allowed to handle or control output during the same period.

The real time digital system is at the border of engineering and business. It is a highly complex system engineered from various data processing, communications and sometimes other components to accomplish a job in business, industry, science or defense. It has to be understood to be effectively controlled and audited. The CPA must assert his position in this border area or it will be slowly eroded as electronic systems take over more areas in the conduct of business. To maintain and extend his position, he should conceive his purpose in the scheme of things as a professional, independent examiner of business, and should tackle any job existing in the framework of all of these new developments.

CHAPTER

5

The Impact of EDP on Internal Control

Internal Control With EDP

An Internal Control Checklist for EDP

Evaluating Internal Controls in EDP Systems

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Internal Control With EDP

THE RAPIDITY with which electronic data processing is revolutionizing our "paperwork" world is amazing, if not breathtaking. EDP has exposed the business community to an environment which is unique only unto the world of electronics and computers. In fact, the presence of an electronic computer has certainly affected the accountant's traditional paperwork-oriented methods. Perhaps this effect is best recognized by the change in appearance of many ledgers, journals, and source documents. But methods of implementing internal control, too, have been affected. For many years internal control has been identified with such characteristics as the division of duties, a network of authorization and approvals, arithmetical verifications, and lines of responsibility; however, with the ever-increasing centralization of data processing through the use of large-scale electronic computers, there has been a tendency to consolidate many of these functions.

For example, in processing sales on account, a computer system, by just one pass of the data, can record the sale and the receivable, modify the inventory file, compute the cost of the sale, test to see if the inventory needs to be replenished, type a purchase order if necessary, and prepare an invoice and shipping documents which relate to the original transaction. Since the computer has performed all of these operations without manual intervention, not only has there been no division of duties, no authorizations or approvals, nor any lines of responsibility, but the incredible accuracy of the computer has even eliminated the need for arithmetical verifications. It seems fitting, therefore, that one examine more closely existing internal control methods in order to determine what real effect EDP has had upon them. The first portion of this paper will explore this. Thereafter, a discussion outlining "new methods of control" will follow. In addition to outlining a new control network for EDP, we will also attempt to show which of the traditional methods of implementing internal control are compatible with electronic data processing systems.

The American Institute of CPAs defines internal control in this manner:

> Internal control, in the broad sense, includes . . . controls which may be characterized as either accounting or administrative. . . .
>
> (a) Accounting controls comprise the plan of organization and all methods and procedures that are concerned mainly with, and relate directly to, the safeguarding of assets and the reliability of the financial records. . . .
>
> (b) Administrative controls comprise the plan of organization and all methods and procedures that are concerned mainly with operational efficiency and adherence to managerial policies. . . . [1]

One can note that the above definition delineates between internal administrative control and internal accounting control (including internal check). The committee on auditing procedure of the AICPA resorted to this division of internal control in order to more clearly indicate the auditor's responsibility for the review of internal control. From a systems standpoint, however, the entire concept must be considered.

Internal administrative control is characterized by the organizational independence among departments and lines of delegated authority. The impact of EDP upon this group of controls has not been as far-reaching as in the case of internal accounting control and internal check. Nevertheless, some of the characteristics of internal administrative control are affected. The organizational independence which now exists between an operating department and accounting is undergoing a change in emphasis. Consider, for example, the following statement:

> . . . I believe . . . the internal control function will have excellent results in the long run by focusing attention on the essential point of control (i.e., where the transaction takes place) and away from some

[1] *Statements on Auditing Procedure No. 29: "Scope of the Independent Auditor's Review of Internal Control," American Institute of Certified Public Accountants, 1958, pp. 36-37.*

of what we now consider controls which are established in accounting departments.[2]

The foregoing statement might be taken as a direct violation of the premise that no department should control the accounting records relating to its own operations, but this is not the case. What is implied is that the formal preparation of source data, for processing by the EDP system, will in the future become the responsibility of operating departments as data processing becomes more integrated and the desire for up-to-the-minute results increases (consider the widespread use of the data transmission devices which transmit data by wire from outlying district offices to the home office EDP unit). Thus, organizational independence will be vested, not in the separation of the operating department and the accounting department, but in the separation of the operating department and the processing unit or computer facility. Furthermore, lines of responsibility are drawn within an organization to facilitate conformance with prescribed managerial policies. EDP, however, interferes with a management principle which recognizes that with the placement of responsibility must go the delegation of authority. In the past, lower level management has been free to interpret general managerial policies handed down from above in order to carry out the day-by-day operations of the business. With the conversion to EDP, these groups of managers tend to lose their authority to make decisions, as the computer is now being programed to execute these decisions for them.

Internal accounting control constitutes another element of the existing internal control network. The function of this group of controls is to check the accuracy and reliability of the accounting data. The characteristics of internal accounting controls permit them to be classified under one of three major subheadings—control total techniques, authorizations and approvals, and comparisons.

Control total techniques assure processing accuracy. The provisions made for the use of controlling accounts and the fundamental practice of batching are common examples of methods now being used to assure processing accuracy. Computer systems, however, afford a means for attaining unprecedented accuracy. The element of human error is no longer present when data are processed electronically. Although control totals might no longer be necessary to assure processing accuracy, they

[2] *Arthur B. Toan, Jr., "The Auditor and EDP,"* The Journal of Accountancy, *vol. 109 (June 1960), pp. 45-46.*

are still required to prove that there has been accurate transmission of data to and from the computer facility. Emphasis is being placed, therefore, not upon techniques to assure processing accuracy, but upon new techniques which make certain of transmission accuracy.

Sound accounting control is also believed to be vested in a system of authorizations and approvals. The ability of the computer to make logical, comparative, "yes-no" decisions permits a set of predetermined criteria to be introduced into the stored program, thereby granting the computer the power of review. Input data can be accepted and processed, or rejected on the basis of these criteria. Since the present system of authorizations and approvals is nothing more than a review function—judgments being based upon predetermined criteria—it is apparent that the computer, through its stored program, is capable of performing such routine tasks as: granting credit, reordering stock, writing off delinquent accounts, issuing purchase orders, approving vendor invoices, and preparing checks. These are certainly not all of the duties which might be assumed by the computer, but they are sufficiently representative to indicate how the system of authorizations and approvals is now part of the computer's program.

The third classification of internal accounting control, which likewise attests to the accuracy and reliability of accounting data, is based upon comparisons. Comparisons take a variety of forms: time cards and clock cards are compared to prove the accuracy of the payroll; vendors' invoices and receiving reports are compared to authenticate the receipt of material; sales orders are compared with catalog prices to check quotations; and cash remittance advices are compared with accounts receivable to determine the accuracy of customer receipts. These, then, are a few examples of comparison techniques. The computer's ability to make logical comparative decisions of an "equal to," "less than," or "greater than" variety allows representative data to be fed into the computer with the result that the computer itself can make similar comparisons of data.

Internal check, another element of the present internal control system, represents the measures adopted to safeguard the assets. The division of duties (so that no one department, group, or individual authorizes a transaction, records it, and holds custody of the assets) is a well-established principle of sound internal control. The electronic data processing system, however, is designed to facilitate the consolidation of files and transactions. Payables, receivables, inventory records, credit information, salary and wage rates, and ledgers are all a part of the file system of the computer facility. Likewise, every transaction which makes use of or affects these files is processed through the computer. This mass consolidation of files and transactions certainly affects traditional internal control methods.

This, then, illustrates the effect of electronic data processing upon the existing internal control system. In almost every instance it has become apparent that many of the present methods of implementing internal control have been pre-empted by the computer facility. Manual techniques and decentralization have given way to electronic mechanization and consolidation. The internal control system which had been nurtured by management and acountants alike, for almost a decade, must now be re-evaluated, redesigned, and reinstituted in the terms set forth by the EDP environment. The rationale supporting such innovations has been well expressed by Arthur B. Toan, Jr.:

> We should make a mistake if we thought of EDP as just a piece of equipment or technique for handling clerical and administrative work. It is also a potent psychological force in its own right which stimulates innovation and creates a degree of drive and receptivity which helps to turn ideas into realities. Those who work with EDP delight in challenging basic concepts of record-keeping, of organization and of management itself. . . .
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> EDP specialists have, in short, a striving for accomplishment which is not unlike that of the truly professional accountant. . . . [3]

How, then, might an internal control system be designed and wedded with the computer facility, when so many of the present methods of implementing internal control seem ineffective. EDP, however, has an answer, for it has in readiness a whole host of new methods—a few of which even represent new applications or modifications of some of the older and more familiar methods.

Internal control by EDP

Felix Kaufman speaks of the automation of internal control via EDP and notes that the "electronic data processing system's powerful checking abilities make it a center of control."[4] He furthermore seems to lend support to a premise that control is now a part of the computer facility

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[3] *Ibid., p. 43.*

[4] *Felix Kaufman,* Electronic Data Processing and Auditing, *The Ronald Press Company, New York, 1961, p. 146.*

when making introductory remarks relative to the effect of EDP upon internal control:

> Systems employed to date, using manual and semiautomatic means for processing, have not achieved . . . internal control goals. Their controls are, in a sense, a separate procedural system, even though superimposed on regular operating procedures. The effectiveness of these controls depends primarily on the continuous vigilance of people, whereas in electronic data processing the means to integrate the procedural system and the control thereof is present.[5]

EDP takes no exception to the American Institute's broad definition of internal control. Only the present methods of implementing internal control are being affected. Since emphasis has been placed exclusively upon the computer facility, it seems logical that these new methods might be characterized by the three elements present in any EDP control system—input controls, processing controls, and output controls.

Source data will naturally continue to be generated from the operating departments. Input controls, however, not only ensure that all valid data are being processed, but afford the computer a means for summary checking processing accuracy. The control methods introduced here are not new; they are merely adapted to fit a computer-oriented data processing system.

Batching with a control total. Under batch accounting methods source documents are accumulated into batches which constitute economic processing groups. Control totals customarily represent dollar amounts; but if the input is not expressed in dollars, or as in the case of a random access facility where input need not be sorted into any logical transaction group or sequence, use of some other control total is desirable. These other control totals (commonly referred to as "hash" totals) represent insignificant totals of some data field which is common to all documents in the batch. Common examples of such data fields are quantities, item codes, and account numbers.

Serial numbered forms. This practice is certainly not new, but is included because of the computer's ability to control serial numbers. Serial numbers of certain documents which constitute input (such as requisitions, vouchers, and receipts, as opposed to invoices and checks) might be introduced along with account codes, quantities, etc., and stored

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[5] *Ibid., p. 123.*

within the computer. At periodic intervals the serial numbers of those documents which had not as yet passed through the data processing unit could be determined by the computer for review and follow-up. This would assure that all data are being processed through the computer facility.

Digit verification devices. Peripheral devices are available which ensure the accuracy and validity of all input data. Although many digit verification devices are not associated electronically with the EDP system, this equipment is just as much a part of the system as is the electronic computer and its components. For example, International Business Machines' 56 Verifier is one type of digit verification device. This machine checks and verifies card-punching. The operator, using the original source documents and the punched cards, rekeys the data into the keyboard of the Verifier. The machine compares what has been punched and what is rekeyed; any difference will cause the keyboard to lock. Another digit verification device is National Cash Register's Check Digit Verifier. This machine is designed to test the validity of an account number before it is recorded into tape or cards by means of a programed mathematical formula. Thus, the presence of any one, or a combination, of these or similar devices contributes to the effectiveness of input controls.

Processing controls comprise by far the largest and most comprehensive group of new methods of controls offered by EDP. Not only is unprecedented accuracy and reliability attained in processing accounting data, but the impersonal nature of the computer permits transactions and file records to remain independent and assures that prescribed managerial policies will be carried out with a high degree of consistency. Processing controls are made up of checks built into the system by the manufacturer and checks capable of being incorporated into the computer's program. The first group to be discussed relates to the "built-in" features, or what are sometimes referred to as "hardware" controls.

Parity check. The most universal of all machine circuitry controls is the parity check. This particular check verifies each binary-coded character (a character being a letter of the alphabet, a number, or perhaps a special symbol, each of which is represented by a certain combination of zeros and ones). By adding another bit (a zero or one) to the binary code value when characters are being converted to machine code by some input medium, a condition is created whereby every character is made up of an even or odd number of ones. Computers designed to recognize an even parity count, for example, would process information containing only an even number of ones. The computer, therefore, is designed to check this situation continuously at every point where information is transferred in its system. Any addition or loss of a bit, thereby distorting the character, will cause the machine to stop or correct itself by switching to an alternate program.

Duplicate circuitry. Some computers duplicate the more essential circuitry of their main arithmetic unit. In this way calculations are carried out twice to ensure accuracy.

Dual arithmetic. In this case the computer does not possess dual circuits, but automatically performs every computation twice using the same circuitry. The results are then compared. A few systems are capable of performing the second calculation with the complements of the true figures.

Echo check. This method is often incorporated into the system at points where information is transferred. Here a feedback mechanism echoes a character back from the point of transmission to its source. For example, when information is to be transferred from the computer to magnetic tape, the recording device senses what has been received and a signal is echoed back to the computer from the tape unit. This signal is then compared for accuracy.

Dual heads. This is another method similar to echo checking but is used in checking the transmission of recorded information. A reading device senses recorded information and transmits it instantly back to the source for comparison. Dual heads represent a much more effective check than the echo check, since recorded information is checked, not just the electronic impulse.

Overflow check and sign check. The overflow control is designed to indicate whenever an arithmetic function causes the data to overflow the capacity of a counter or accumulator in the computer's arithmetic unit. This prevents the loss of significant digits during computation. The sign control will indicate whenever an arithmetic function is performed on an amount which does not carry a positive or negative designation.

Tape ring. When information is being written on reels of magnetic tape old information is automatically erased. To assure that master files might not inadvertently be used on an output unit, a plastic ring is removed from the reverse side of the tape reel. Without this plastic ring no information can be written on the tape.

Preventive maintenance. Although this control method is not a part of the system per se, it is included under this section of "hardware" controls because it does make use of some of the technical aspects of computer design. Normally a schedule is followed which allows a crew of engineers to devote at least one hour each day to preventive maintenance. Test problems are fed into the computer which check all of its components. A "high-low" voltage test is applied whereby the computer is tested to detect marginal functioning of its circuitry.

These, then, represent the mechanical controls which have been built into the electronic computer's system by the manufacturer. A second group of processing controls, however, represent checks capable of being incorporated into the computer by means of coded instructions and control panel wiring. These so-called "programed" controls are much more sophisticated than many of the "hardware" controls previously discussed. They will now be examined in greater detail.

Record count. A record consists of a group of characters which are normally considered together as a unit, such as the combination of numbers which make up a particular transaction or an account balance. The computer might be programed to count the number of records it processes, and later this result can be compared with a predetermined total. Record counts are generally made a part of the information on every tape reel. Thus, file data can be transferred from one tape to another without fear of loss of records.

Sequence check. This program control permits master records to be checked for ascending sequence while being read for processing. Master records, for example, might be identified consecutively by customer number or account code. This control method assures that a file is processed in its proper sequential order.

Limit check or reasonableness tests. Predetermined limits (gross pay, the amount of an invoice, or the amount of a purchase order) can be established as a part of the computer's program. When processed data exceed these predetermined limits, the machine can be instructed to stop and special handling techniques can be designated by the on line printer.

Proof figures. A proof figure can be used to check an important series of multiplications. An arbitrary figure, larger than any multiplier, is selected. Each multiplicand is multiplied once by its true multiplier and then again by the difference between the multiplier and the proof figure. Upon completion of a series of multiplications, the total of the products resulting from both multiplication is compared with the product of the total of the multiplicands and the proof figure. They should be equal.

Reverse arithmetic. This is another method which might be used to ensure that a multiplication has been made correctly. A calculation of x times y equals z might be checked by multiplying y times x and subtracting z to determine that the result is zero.

Cross footing balance checks. Cross footings have long been used by accountants in checking the accuracy of individual postings. For example, by vertically adding the net amount of invoices and discounts allowable, the totals, when cross footed, should equal the total gross amount of the invoices. The computer, however, can be programed to perform this function.

Identification comparison. This method permits comparisons to be made of common items. By programing a compare instruction invoice, amounts can be compared with predetermined credit limits to facilitate limit checks. All in all, identification comparison enables data fields to be machine-checked against one another in order to prove the accuracy of matching, coding, balancing, and file record selection.

Tape labels. A tape label is a part of the records on each reel of magnetic tape. Certain identifying information can be written on the tape in the form of a lead record. Desirable types of information which might be made a part of the tape label are: nature of the information on the tape, processing directions, frequency of use, earliest date the reel might be used as a new output tape (frequently referred to as the "purge" date), control totals (record count, for example), and name of the individual responsible for the tape. The computer can then be programed to read this information before processing the tape.

Blank transmission test. The computer system might be programed to monitor data fields at transfer points for blank or zero positions. The blank transmission test might be used to detect the loss of data and to prevent the destruction of existing records in file storage.

Alteration test. Failure to update a file may be sensed by comparing the contents of the file before and after each posting. This test is similar to identification comparison.

Checkpoint or "rollback" and restart procedures. These methods permit the computer to continue processing from the last checkpoint, rather than from the beginning of a run, in case of an error or an interruption in the program. Checkpoints are predetermined in the program and at certain intervals input-output records, as well as the contents of certain storage areas, are recorded internally in the computer. At the same time, if desired, accuracy of processing up to the checkpoint can also be established. In the event of an error, restart procedures permit the program to revert back to the last checkpoint and resume processing.

Error routine. After a programed check signifies an error in reading or writing (for example, the tape file may be out of sequence, or the disk file might not be properly updated through execution of the alteration test), a programed error routine should cause the operation to be performed once again. If there is still an indication of an error, certain predetermined formal procedures should be made available to the operator outlining what action is to be taken.

These, then, represent some of the more common checks which can be made an integral part of the computer's stored program. In a sense, these "programed" processing controls are optional, but, if there is to be sound internal control, they should be made an inherent part of every computer program. The accountant must be as equally familiar with each of these programing control features as he is with existing control applications, for, in many cases, these new methods of control have superseded their manual counterparts.

Output controls

Output controls accentuate the role of the computer facility as a center of control. Insofar as input controls ensure that all data are being processed, output controls assure that the results are reliable and that no unauthorized alterations have been made to transactions and records while in the custody of the electronic data processing unit. Output controls promote operational efficiency within the computer facility over records, programs, processed data, and machine operations.

Comparison of control totals. In reality, the most basic of all output controls is the comparison of batch control totals, after processing, with those which accompanied the source data to the computer facility. It will be recalled that the nature of these control totals were discussed under input controls.

Separation of duties. This is certainly an old method, but in new guise. Within the computer facility there should be at least four separate and distinct groups of individuals—the planners (systems specialists and programers), the machine operators, a group responsible for output controls, and a record librarian. In this way no one group has direct and complete access to the record-keeping system. For example, the planners, who are intimately familiar with the stored program and the entire EDP system, should have no contact with the day-to-day operations. On the other hand, the machine operator's knowledge of detailed programs and the historical records should be sufficient enough to enable him to perform his job as an operator effectively; too much knowledge can lead to intentional or unintentional manipulation of data, but too little knowledge might reduce the efficiency of the entire data processing unit. Responsibility for output controls might be identified with the internal audit function or could be assigned to a separate group of individuals organizationally responsible to the data processing unit. The presence of a record librarian assures that programs, as well as historical records, will be adequately controlled. By assigning one individual—one who has no relationship whatsoever with any of the other data processing activities—the responsibility for the custody of all file information, only authorized changes can be introduced into computer programs or historical records.

Control by exception. The output control group would make comparisons of control totals; they would also be responsible for investigating persistent errors, amounts which exceed predetermined limits, and any differences between file records and physical inventory counts or account confirmations. Summaries might also be prepared comparing current data with historical data to note any other significant changes.

Information retention program. Programs, transaction data, and records must be meticulously controlled. Master tapes which contain computer programs are usually duplicated, with one copy retained in a locked storage area. A formal system of authorizations might be instituted for making any program changes. File records might be periodically read out of the machine, so that, in the event of losing some portion of the file data through operator error, an opportunity remains available for reconstructing the file records. A policy must also be set relative to the retention of transaction data since tape reels are expensive and they can be used over and over again.

Systematic sampling. Tests might also be made, by the control group, of selected individual items being processed. Individual transactions can be traced from the originating department, through the computer facility, to the records stored internally by the computer. Such tests would assure that transactions are being processed both accurately and in accordance with prescribed policies and procedures.

Numerical accountability. This practice is again an old one. Although invoices, checks, and all preprinted forms are presently controlled by numerical sequence, numerical accountability might be extended to all types of output—preprinted forms or otherwise, and including data generated by the on line printer. For example, a program can be designed to print out instructions or data to the operator. If numerical control is exercised over this type of print-out too, reasonable control can be assured over machine operators, as well as all the various forms of output data.

Separate runs. The ability of the computer facility to consolidate so many functions might require in some instances that the same data be run through the computer more than once. For example, McCullough[6] illustrates this by inferring that there might be three inventory runs: a run to produce accounting totals; a run to produce data for storekeepers; and still another run to provide information to purchasing. Separate runs, therefore, represent an effort to establish continunity and agreement among successive related computer runs since control totals can be established during each run and later compared.

In fact, there is another advantage to separate runs other than that of control—this being processing efficiency. Many computers are programed to perform a number of functions by passing the data through the machine only once. The time saved by this single run, as opposed to separate runs, is not so significant when compared with the problems which could arise in the event of a data-transmission error or an error in processing. Not only are these types of errors difficult to localize during a single run, but also a great many file records are affected. Hence, separate runs might even be a more efficient way of processing data.

Control over console intervention. The likelihood of console intervention is a problem common to all computer facilities. Programed controls are unable to prevent the operator's ability to interrupt processing and manually introduce information into the computer through the console. Likewise, even if the stored program does possess an instruction to print

[6] *Thomas E. McCullough, "The Auditor Uses the Computer," The Internal Auditor, vol. XVI December 1959, p. 35.*

out all information introduced via the console, the machine operator still has the opportunity to suppress the print-out. Perhaps this entire situation has been magnified beyond reality. It seems improbable that the machine operator could manipulate the records successfully when his knowledge of the detailed program is limited (if there is adequate separation of programing and machine operator responsibilities), and when there is such a large number of complex file records requiring alteration. Research on this subject, however, revealed only one reference in the literature (cited by the same author in two separate articles)[7] to a defalcation which was actually attributed to the unauthorized manipulation of a computer program. Nevertheless, if there is proper separation of duties (with the operator accounting for processing time as is customary in most computer installations), if there is rotation of operators, and if numerical accountability is exercised over all types of print-out, chances for intervention will be minimized.

EDP has certainly provoked a number of new ideas with respect to internal control methodology. The talk of automation of internal control cannot be scoffed at, and the growing importance of the role of the computer facility as a center of control is gaining momentum. When accountants are instructed to review the system of internal control, they cannot afford to overlook the computer facility. They must recognize that it is now an integral part of the internal control system.

In a manual, as well as in an electronic data processing system, data must be introduced into the system (input), processed, and the resultant information (output) communicated to management and other interested parties. Thus, a sound functional internal control system is equally important in either system. However, traditional methods of implementing internal control are affected in the presence of EDP. The foregoing discussion illustrates that: (1) Traditional methods of implementing internal control need only be adapted in the input-output phases of an EDP system; and (2) separation of duties, authorizations, approvals, manual comparisons, recomputations, and the like, are either unnecessary or should be extremely modified in the processing phase of an EDP system.

In support of conclusion (1) it has been shown how batch control totals, serial numbered forms, and digit verification methods all can be

[7] *William L. MacDonald, "The Auditor and the Computer," The Canadian Chartered Accountant, vol. LXXXI September 1962, p. 256, and "Audits and Audit Trails—Part 1," Data Processing, Proceedings of the 1961 International Conference of the National Machine Accountants Association, vol. IV, National Machine Accountants Association, Toronto, 1961, p. 149.*

used effectively when data are introduced into the electronic system. Similarly, separation of duties, comparison of results, and numerical accountabilities are equally important, but especially in the output phase of an EDP system. Evidence has been offered as well in support of conclusion (2). It was emphasized how an electronic computer can perform so many processing steps without manual intervention. Thus, the need to superimpose control steps during processing operations becomes less important in order to ensure accurate processing due to the mental and moral frailties of the individuals in the system. It was shown that many controls have been built into or programed into an electronic computer by manufacturers and programers alike in order to continually test the accuracy of the processing unit. Emphasis has shifted, then, from controls which test employee integrity to those which test machine accuracy.

Accountants today must be aware of the characteristics of internal control which have changed or which have experienced a change in emphasis due to the advent of EDP. Accounting systems can neither be designed nor audited properly unless the real effect of EDP upon internal control is thoroughly understood.

H. BRUCE JOPLIN, CPA

An Internal Control Checklist for EDP

ACCOUNTANTS, AUDITORS, and other persons concerned with the establishment of good internal controls have long sought a method of evaluating the adequacy of controls incorporated into electronic data processing systems. Those without extensive experience in computer operations who have attempted to penetrate the labyrinth of EDP will readily appreciate the value of an objective basis from which to launch their inquiry into this phase of automation. An internal control checklist such as is presented in this article can serve as an invaluable aid in this regard.

From the outset it should be stated that the use of a checklist does not obviate the need for judgment and discretion on the part of the reviewer; it does provide a framework around which an informed decision may be reached regarding the adequacy of the system of internal control. For example, a negative answer to any question or group of questions is not prima facie evidence of a weakness in internal control but must be evaluated in the light of the entire system. To do this the reviewer should inform himself as to the nature, scope, and capabilities of this particular EDP system. This knowledge may be obtained by a review of flow charts and input and output formats; observation of computer operations; discussions with computer manufacturers' representatives; and review of computer reference manuals.

Mastery of a certain amount of computer jargon is an additional requisite to the evaluation of EDP systems. Since the reviewer must communicate with computer-oriented people who typically do not understand more than a minimum of accounting terminology, it is incumbent upon him to enter the discussion as well prepared as possible. The checklist presented herein assumes a reasonable knowledge of computer terminology.

To provide continuity of thought, certain assumptions have been made in developing the model checklist. Generally, a fully integrated, tape-oriented system with no parallel operations and few, if any, intermediary print-outs has been assumed. The reviewer should modify his procedures for evaluating the system of internal control to fit the equipment configuration and stage of conversion he encounters.

An internal control checklist for EDP should be divided into logical segments to facilitate an orderly approach by the reviewer. The following sections have been selected as appropriate for our discussion: (1) organization of the EDP department; (2) standardization of procedures; (3) computer program maintenance; (4) input procedures; (5) computer processing procedures; (6) magnetic tape control; (7) Physical condition and maintenance.

The importance of each section will be considered briefly, followed by examples of the type of questions that could be included in an internal control checklist. Space does not permit a complete listing of all appropriate questions.

The proper segregation of duties is just as important, if not more so, in an electronic data processing system as it is in a conventional accounting system. There is a greater concentration of responsibility for data processing lodged in the EDP department than in any other single unit. It is important that this department be so designed as to permit maximum co-operation between work units yet provide for physical and organizational separation. The reviewer should regard the absence of written instructions and manuals and/or the prevalence of oral instructions as weaknesses in internal control.

1. Is the EDP department independent of all operating units for which it performs data processing functions?

2. Are the following work units physically as well as organizationally separate?

(a) Computer center
(b) Control unit
(c) Program and tape library
(d) Systems and programing units

3. Is there a current operating manual for the department?

4. Are current organization charts and flow charts available?

5. Is there a schedule of all active programs, including a brief description of the function of each, date of approval, and identification number?

6. Is access to the computer center limited to persons having a legitimate mission therein?

7. Is access to control data restricted to employees of the control unit?

8. Is the control unit responsible for recording and expediting all data processed by the EDP section, including control over the number, due date, and distribution of reports?

9. Are approved copies of all computer programs and necessary supporting documents maintained in the library and issued to interested persons only upon written authorization?

10. Are systems and programing unit employees forbidden to operate computers on regular processing runs?

Standardization of procedures

Although each computer is unique in its purpose, there are many programing techniques and procedures which are common to all programs. It is desirable that these techniques and procedures be standardized and set forth in a programing manual. This manual will contain a written record of all policies, procedures, and techniques which are to be used throughout the data processing organization. Such a manual will facilitate communication among programers, assist in training of new personnel, and prevent the development of conflicting procedures.

1. Is there a standard format for the program file which should be assembled for each program?

2. Are flow charts and block diagram symbols and procedures standardized?

3. Are program testing procedures well established?

4. Are program techniques standardized for the following: Table look-up or search methods? Use of program switches? Initialization routines? Tape record blocking?

5. Are halt addresses standardized as to core location and use?

6. Are symbolic programing labels or tags standardized?

7. Have all standardized procedures been compiled in a programing manual and is the manual current?

Documentation important

Complete and thorough documentation of computer programs is a requisite to controlling the operations of programing and systems units, to safeguarding the assets of the company, and to expediting changes in, and patching of, operating programs. In the early stages of development, computer programs are altered and patched so frequently that proper documentation is difficult to achieve. However, at the time a program becomes operational, the documents which support and explain the program should be prepared and filed in the library. As subsequent changes are made, the file must be revised accordingly.

Are program changes cleared through persons of authority other than programers directly involved in the preparation of programs?

Are program changes documented as to the following?

1. Reason for change
2. Effect of change
3. Prior period adjustments necessary

Is there a program file for each computer program containing the following information?

1. Specific program name and number
2. The purpose of the program
3. Agreements as to: when source data is to be ready for processing; what output is required, format, etc.; when reports are due; how various transactions and exceptions are to be handled; what coding will be used (Written documents containing this information should be reviewed and signed by all department heads concerned. This assures that the problem has been thoroughly investigated and agreement has been reached before programing begins.)
4. A narrative description of the program
5. A general block diagram
6. A detailed block diagram
7. Complete operating directions. These instructions should be clear and simple. They should be so complete that no oral instructions are required to operate the program. These instructions should: identify tape units on which various input and output files will be mounted; describe any action required regarding external tape labels; specify console switch settings; list all program halts with prescribed action for each; describe restart procedures if other than standard; describe any exception to other standard routines
8. A description of all input data required
9. A description of output data required: form numbers, approximate quantity, number of copies, etc.
10. Disposition of input material, defining exactly what is to be done with all input material; where to deliver; how long to retain
11. Detail layout of: tape input records, tape output records, punched card input and output format, printed output including samples
12. Layout of storage locations: input, output, and work areas; subroutines; constants and variables

13. Description and example of any control card which may be necessary

14. A sample of the printer carriage tape

15. A dump of the program now in use.

Input procedures

The exactness with which computers follow instructions requires that data entering the system be translated into machine language in correct form and content. If input is captured accurately and completely, the processing of data will be relatively simple once computer programs have been debugged. The development of formal procedures, the presence of written instructions, and the minimization of transactions requiring special treatment will increase input accuracy and strengthen internal control.

Is the number of basic types of input documents limited so as to facilitate control and processing efficiency?

Are all input documents press-numbered?

Are all numbered documents accounted for by the control unit?

Are data processed in serially numbered batches?

Are all source documents identified by batch number and canceled to prevent reprocessing?

Are data controlled by the number of documents processed and by hash totals as well as by dollar amount?

Does the control unit use a document register or other positive method of comparing machine run totals with control totals?

Is responsibility fixed, and are adequate procedures in effect, for tracing and correcting input errors?

Are corrections identified and recorded in such a manner that duplicate correction will not occur and subsequent audit will be possible?

Are all instructions to keypunch operators (or bookkeeping machine operators preparing paper tapes) written in clear, concise form?

If the computer writes checks or other negotiable instruments, are the requisition and use of blank stock closely controlled?

Computer processing procedures

Processing, as used here, includes all functions performed from the point at which the computer receives data in machine language to the final report. During this time the method of storing and transmitting data may change many times. The nature of data may be altered by other data already in storage or by factors built into programs. The auditor should be familiar with how data are processed, in what form, and with what results. This he may learn from flow charts and block diagrams.

Do programs positively identify input data as to date, type, etc.?

Do programs test for valid codes in input data, and are halts or print-outs provided when invalid codes are detected?

Are changes in program rate tables and other constants initiated in writing by persons authorized to do so, and are all such changes recorded and retained for audit?

Are all instructions to operators set forth in writing in clear and unequivocal language?

Are operators cautioned not to accept oral instructions or to contact programers directly when errors are detected?

Is there a positive follow-up to determine if corrections are made on errors found by the machine?

Are all halts (except end of job) and errors recorded and the record retained for audit?

Is the use of external switches held to a minimum, and are the instructions for their use set forth in writing?

Are the situations whereby data may be inserted or extracted by the use of the console set forth in writing and limited to circumstances which cannot be handled through the stored program?

Are console print-outs controlled and reviewed by persons (other than operators) who are familiar with the activity being performed?

Are console print-outs labeled so as to be reasonably intelligible?

Are account codes, employee numbers, and other identification data designed with self-checking test digits, and does the program test for these digits?

Are checkpoints provided in lengthy processing runs, and are program or external restart instructions provided in case a checkpoint fails to balance?

Is a computer usage recorded on a positive basis by program as to run-time and set-up time and by nonuse as to maintenance time and off time?

Magnetic tape use

In EDP, data processing activities are organized around files as opposed to functions as in most manual systems. For example, in the typical EDP installation the hash receipts processing function will be subordinated to the accounts receivable file maintenance. The proper control over, and maintenance of, these files is of major interest to the reviewer.

Are there physical controls to prevent inadvertent erasure of tapes?

Are there formal procedures for preventing premature reuse of tapes?

Do external tape labels contain the following: Reel number? Serial number? Number of reels in the file? Program identification number? Date created? Retention date? Density? Drive number?

Do header labels have the following data: Program identification number? Reel number? Date created? Date obsolete?

Do trailer labels have the following data: Block account? Record count? Hash totals? End of reel or end of file designation?

Do programs test for header and trailer labels each time a new tape is accessed or the end of the reel is sensed?

Has a policy been established for the retirement of tape reels which have excessive read or write errors?

Physical condition

Computer manufacturers have made considerable progress in insulating their equipment from environmental influences. Nevertheless, certain precautions are still necessary to prevent damage to hardware and tape files. In addition, regular maintenance by qualified engineers is an integral part of assuring continued computer performance and accuracy. The reviewer should inform himself of maintenance and other requirements applicable to the computer under review.

Has a policy been established regarding visitors, neatness, smoking, etc., in the computer center?

Is the hardware serviced by qualified engineers on a regular basis?

Are manufacturer's cleaning recommendations for the computer center strictly followed?

Are manufacturer's temperature and humidity requirements maintained?

Are magnetic tape reels stored according to manufacturer's specifications?

The use of an internal control checklist will greatly facilitate the development of objective criteria for the evaluation of the system of internal control in EDP application. Separation of the different facets of an EDP operation into manageable units will speed the reviewer's understanding of the system as a whole and can provide him with a basis for controlling the activities of the EDP department.

W. THOMAS PORTER, JR., CPA

Evaluating Internal Controls in EDP Systems

THE EVALUATION of the system of internal control is a point of departure in auditing. Such an evaluation serves as a gauge of the quality of the system. It also gives the auditor the foundation upon which he will construct his examination and build his conclusions. The importance and increased emphasis on the evaluation of internal control are clearly revealed by a review of auditing literature. R. K. Mautz and H. A. Sharaf wrote:

> Because the extent and effectiveness of internal control is so important in audit programing and performance, a prudent practitioner will tend to give this phase of the examination a full measure of emphasis. At best, internal control is a rather amorphous subject and difficult to comprehend and reduce to satisfactory workpaper notes. Yet no part of the examination is more important than his review and evaluation of internal control. Also, there is no area in which he can be of more real assistance to his client than by scrupulously examining and reporting on the client's control procedures.[1]

Although internal control does not lend itself to any simple set of

[1]*R. K. Mautz and H. A. Sharaf,* The Philosophy of Auditing, *American Accounting Association, Madison, Wisconsin, 1961, p. 146.*

rules by which it can be evaluated, it has historically been evaluated by the auditor through:

I. Observation, inquiries, and review of manuals and charts to determine whether: (1) The formal and informal organization of the company clearly establishes and specifically prescribes a functional segregation of duties between people responsible for: (a) authorization of the transaction; (b) recording and processing of the transaction; (c) custody of the assets involved in the transaction. (2) The financial and accounting procedures are sufficient to assure that: (a) Transactions are reviewed sufficiently to establish the propriety and accuracy of their recording. (b) Data processing flow permits detection and correction of errors in operating and financial data and reduces such errors to the level permitted by management. (c) Reports are required and prepared to reflect the responsibility for the authorization, performance, and review of financial and accounting transactions.

II. The selection of actual transactions to determine whether the purported policies, procedures and controls are operating as described.

The effect of electronic data processing on the evaluation of the system of internal control largely centers on point II above, the testing of the system. In any system, EDP or otherwise, a review of the organizational aspects, procedural controls, and administrative practices is necessary to establish the extent of the audit examination and to make constructive suggestions about improving the system. But obviously, EDP affects the nature of such a review. The importance of systems development and programing practices and documentation, input-output controls, programed controls, tape library procedures, and computer operating controls require the auditor to observe different activities, ask different questions, and review different manuals and documents than he would in his review of a non-EDP system.

Conventionally, the auditor has selected actual accounting transactions that have been previously processed by the client to test the system. Typically, this approach calls for the tracing of a "representative" number of transactions from the recording of the source documents through whatever intermediate records might exist to the output reports or records produced. Such an approach is taken without any regard to the manner in which the output was actually developed. It is based on the logic that if the source data or system input can be proven correct and if the results of the system accurately reflect these source data, then the output must be correct and the manner in which the system processed the data is inconsequential.

In an EDP-dominated situation, such an approach has been called the "around the computer" approach to testing the system. This approach is the one which, in the majority of EDP installations, has been taken by auditors. Auditors have been using this "around the computer" approach because:

1. It is a familiar method.
2. It does not require technical knowledge of the EDP equipment.
3. The relatively unchanged audit trail conditions encountered in the EDP installations have not required a different approach.

An often unstated but perhaps more significant reason for the auditor's use of the "around the computer" approach is the auditor's unwillingness to come to grips with EDP.

The other approach to the testing of the system is the "through the computer" approach, which follows the concept that, if the controls and procedures incorporated in computer programs are effective and if a proper control of computer operations is employed, then proper processing of proven and acceptable input is bound to result in acceptable output. Such an approach is entirely dependent upon the consistency of processing operations found in computer operations.

In addition to an overall review of the EDP system, this approach obviously requires an explicit knowledge of input and master file record layout, a fairly comprehensive knowledge of computer operations and built-in and programed controls, and a thorough understanding of the development and use of "test decks."

In my opinion, often the conventional audit approach of testing the system by selecting actual transactions previously processed by the client is incomplete and inexact. In some cases, the transactions selected do not include the unusual ones requiring exception handling. In addition, the auditor, even with "representative" tests, can never be certain that the individuals carrying out the system actually do what they say they do or are supposed to do.

But with the advent of electronic systems, the operations research concepts of "models" and "simulation" appear applicable in the auditor's testing approach. The "model" is the client's computer program:

> . . . complete and accurate in all respects, not subject to the deviations caused by human idiosyncrasies or human temptation . . . containing in very specific language the exact instructions as to what the machine is to do. You can tell just what happened to a transaction.[2]

"Simulation" can be performed by the auditor by experimenting and testing the procedural model. The auditor can feed it all sorts of good

[2] *A. B. Toan, Jr., "The Auditor and EDP,"* The Journal of Accountancy, *June, 1960, p. 44.*

and bad transactions to see how the EDP system reacts. These simulated transactions are commonly referred to as "test decks." The test deck is developed by preparing machine-readable data (i.e., punched cards, magnetic tape) designed to simulate every feasible type of transaction and to test specific program controls. These transactions are processed using the existing computer program, and the results of the computer processing are compared with predetermined results. Obviously, the purpose of the test deck technique is to determine for the auditor exactly how a specific processing system will react to particular types of transactions.

> In effect, the auditor allows the automatic data processing system to audit itself by merely presenting the system with a set of test problems or situations which the system cannot distinguish from normal processing activity, and then ascertaining how these tests cases are handled. Since no . . . programing is required to implement a test of this type, the procedure is a relatively inexpensive one from the standpoint of operating costs, and the results obtained are both effectively presented and irrefutable.[3]

While it is true that the computer operating costs to process test decks are rather minimal, it is also true that the development of test decks can be a complex and time-consuming project, and the auditor should be cognizant of the problems involved. However, computers are also able to help develop test decks.

Before discussing the development of test decks, it is important to make two points clear. First, some writers fail to differentiate between test decks and computer audit programs and, as a result, such writing discusses the use of "test programs" in auditing. Test decks, as defined above, are used to evaluate the quality of the data processing system in use. Computer audit programs are used to determine the quality of information generated by the system. Such programs, to be sure, can perform detailed tests and computations. They are more often designed to elicit, from current master files, exception reports or sample selections based on criteria specified and programed by the auditor. Such information is then used by the auditor in his evaluation of the evidence supporting the reasonableness and adequacy of disclosure of the accounts' descriptions, balances, and footnotes in the financial statements under examination. Secondly, some writers and speakers have often

[3] *Department of United States Air Force,* Guide for Auditing Automatic Data Processing Systems, *Government Printing Office, Washington, D.C., 1961, pp. 8-14 and 8-15.*

mentioned another technique of auditing computer records—the review of computer programs. There are several reasons why this method is not very satisfactory:

1. It requires a higher level of programing skill than that required to write the original program. To go through a program which may contain thousands of instructions, complex logic, and numerous switches is an exceedingly difficult job. Even if the auditing profession had enough persons competent to make such an evaluation, it would be too costly.

2. It would not guarantee that the program reviewed is the most current version. Because of the numerous minor changes made over a period of time in the ordinary course of computer operations, the auditor would have to repeat the detailed review periodically, or control program changes, neither of which is very practical.

3. It would not guarantee that the program reviewed is the regular production program being used by the client. The auditor must have assurance that the program he is evaluating is the one which is being used to process transactions and produce financial information.

In my opinion, the only practical answer to evaluating the performance of a computer is utilization of test decks, not reviews of programs. However, a review of the client's documentation used to develop the applicable program is desirable in developing the test deck. Such documents include flow charts, block diagrams, input and output media, exception reports, and narrative descriptions of the procedures and controls in the system.

A review of these documents must be sufficient to give the auditor a complete knowledge of the procedural controls, both manual and programed, in the EDP system so that the transactions included in the test deck check the existence and effectiveness of these controls.

In addition, this review must enable the auditor to determine whether the client's controls are adequate or necessary to achieve the client's control objectives.

In developing and using the successful test deck, there are several important factors which the auditor must take into consideration:

1. He must decide upon the exact point in the system where the test data are to be entered.

2. He must determine the types of transactions to be included in the test deck.

3. He must obtain the master records to process against the test transactions and to compute the predetermined results for comparison with the output resulting from the test processing.

4. He must carefully consider the effects that the processing of the

test transactions will have on the results of the system produced under normal operating conditions.

5. He must obtain the client's regular processing programs and assure himself that the program is used to process the test data.

6. He must make whatever arrangements are necesssary to get the test data prepared and processed and to get the output in the desired form.

Before developing the test deck, the auditor must first decide the point at which he wishes to enter the test data. If the operations and controls in the preparation of input are to be included in the test, the test-deck data must be fed into the input portion of the system as basic source documentation. If only computer operations are being tested, the data may be introduced into the computer operations in the form of punched cards or magnetic tape records.

The inherent advantage of the test deck over the selection of actual transactions is that the auditor may include every type—normal or abnormal—of conceivable transaction in his tests with relative ease. And theoretically, a sample of one for each type of transaction is as statistically sound as a large number because of the uniformity involved in the processing of data.

There are several methods which may be used to construct a simulated transaction deck, all of which require a review of systems and program documentation to gain a complete knowledge of the procedural controls in the EDP system. Although the auditor can prepare entirely imaginary transactions, it may be expedient to select transactions from the client's actual data or from the test data used by the client's programer to check out the computer program. For example, the programer's test deck was used in developing the auditor's test deck to evaluate payroll processing in a large manufacturer. Many of the programer's tests were applicable from an audit standpoint and were readily included in the auditor's test deck. The review of the client's test data also uncovered some outdated tests and areas in the program which were not tested at all. The client's data processing management felt such a review was highly informative and beneficial to operations.

Selection of the client's input data or test data usually will not include all the possible variables, and additional transactions must be created. The determination of possible variables to be tested may be made by analyzing the input record layout. By analyzing the fields of data included on the input record, all combinations of data can be determined. In this connection, several observations should be made:

1. It is not necessary that all possible combinations within all fields be set out as separate problems. Distinction should be made between

variables which merely represent identification data (i.e., account numbers, social security numbers) and those which involve alternate handling. In the case of the former, only a limited number of possibilities need to be included to test the identification routines in the program. To illustrate, Exhibit 1, below, shows the fields and their description for a rate change input card used in a payroll system of the large manufacturer mentioned earlier. The transaction will change an employee's hourly rate and pay code. The transaction is program edited for validity of dates, alpha name, old pay code and rate and whether the new rate is equal to the old rate. In addition, any new rate greater than $10 is excepted. The tests included in the test deck for this transaction were: (a) valid rate change with all other fields valid; (b) rate change greater than $10; (c) valid rate change, old rate wrong; (d) valid rate change, old rate equal to new rate; (e) valid rate change, alpha name wrong.

To test sequence checking and identification comparison routines, a card with a valid transaction number or employee number and containing valid information could be placed out of sequence in the test deck. Additional tests for sequence checking and identification comparison would not be necessary.

2. It is necessary to include at least two of each type of variable requiring alternative handling in order to test the existence and effectiveness of programed controls. For example, in the above illustration, all rates equal to or less than $10 are handled by one processing routine; all rates greater than $10 are handled by an exception routine.

3. The tests should include transactions which determine the processing and handling of the following general conditions: (a) out of

Exhibit 1

RATE CHANGE CARD FORMAT

Card Field	Description
4-12	Social security number
13-14	Transaction code (03)
16	Division
18-22	New hourly rate
24-29	Rate change date
30	New payroll code
31-34	First four characters of last name (alpha name)
48-52	Old hourly rate
75	Old payroll code

sequence conditions; (b) out of limits conditions; (c) routines arising from a major decision point where alternative processing takes place as a result of the comparison of transaction records with master records; i.e., where the transaction identification number can be greater, equal to, or less than the identification number on the master record; (d) units of measure differences; (e) incomplete or missing input information; (f) wrong tape files; (g) numeric characters in fields where alphabetic characters belong and vice versa; (h) characters in certain fields which exceed prescribed length (an overflow condition); (i) illogical conditions in fields where programed consistency checks test the logical relationship in the same fields; (j) conditions where transaction codes or amounts do not match the codes or amounts established in tables stored in internal memory.

Obviously all these conditions cannot be tested with each type of transaction, but the majority of them, if not all, may be tested in processing all transactions included in the test deck.

One of the problems involved in developing a test deck is the difficulty of reviewing its substantive aspects. Apart from a detailed review, which is impractical and time consuming for the audit manager or partner, it is very difficult for the reviewer to get a general idea as to the scope and "rightness" of a test deck. For audit review purposes, it may be useful to construct a matrix during the development of the test data which would indicate the types of conditions tested by each transaction. Such a matrix is shown in Exhibit 2 below. Another device which is helpful in review and which is necessary for the audit workpapers is a transaction listing of the test deck. Such a listing indicates, in code sequence,

Exhibit 2

TYPE OF CONDITION TESTED	Test Transaction Number 0 1 2 3 4 ....n
a	
b	
c	
d	
e	
f	
g	
h	
i	
j	

the information punched or recorded on the transaction input record. This information can be sorted and listed by tabulating equipment. The listing should include a narrative description of the type of test, the objective, and what output will result from the test.

The auditor must obtain the master records in machine-readable form against which the test transactions are to be processed and in visible form to compute the predetermined results for comparison with output resulting from the test deck processing.

With sequential processing, there is usually not much of a problem in obtaining the master records in machine-readable form since the master file is not written over or destroyed in processing the test transactions. There is a problem in random processing since the master records maintained on random access equipment are written over or destroyed by processing transactions. To protect the client's master records, the test deck can be run immediately after the random access file "dump."[4] After the "dump," the master records are on both the random access master files and on magnetic tape. The test data can then be processed against the tape files as discussed above. In such a situation, the client's computer would have to be altered slightly to have the computer "read" and "write" tape rather than "read" and "write" random access files. In situations where the auditor must or wishes to run his test transactions between the "dump" cycles, the random access files may be protected by physically locking the files to prevent writing on them and altering the program so that the "write random access file" instruction becomes "write tape."

In some installations such as the large manufacturer referred to previously, test master records are used, against which the test data are processed by the company's programers in testing the system. These masters, although comparatively few in number, represent actual masters. The advantage of these test masters is the ease with which they can be used and changed to reflect certain conditions necessary for testing, and the ease with which they can be printed out for visible review. For example, the manufacturer uses twenty-four test master records, in punched card form, as a test model payroll master file. These twenty-four records are used instead of the 20,000 employee master record file to avoid time in selecting and printing actual master records. The use of test masters is based on the premise that the computer cannot tell the difference between the processing of a test master record and an actual master rec-

[4]*A file "dump" refers to the transfer or writing of the contents of the random access files on magnetic tapes, at realistic intervals, to provide the ability to reconstruct the file in the event the original file is accidentally damaged or destroyed.*

ord. A variation of the use of client's test master records is the creation, by the auditor, of "dummy" master records for use in testing the system. Such was the case in the test of an automated labor recording system in this large manufacturer.[5]

Although actual master records may be readily obtained in machine-readable form in many systems, it is difficult to get the same records in printed form without advance planning. One method is to time the tests so they are processed with the output master file used to prepare a printed report such as the accounts receivable aged trial balance or an inventory report. Another method is to have an inquiry program prepared which will print out selected master records from the master file to be used in processing the test transactions. Most installations have the ability to inquire into any file, and the auditor may, with a little planning, have his file-searching needs met by a routine procedure.

Obviously, the auditor does not want to have his test transactions affect the results produced under normal operating conditions. Accordingly, he must carefully consider what effects the processing of the test data will have on the results of the system. For example, the output tape resulting from the processing of test data should be clearly labeled so as to prevent improper use and subsequent incorrect processing of operating data.

Any tests that are processed along with actual transactions must be carefully controlled so as to preclude undesired results from taking place. For example, in a test to determine that the open order file was reviewed periodically for unusual items in a medium-sized steel manufacturer, a valid order was transmitted by the auditor from a sales branch location and the shipping copy was destroyed. This order had to be controlled by the auditor to prevent shipping of the order and to ensure subsequent removal from the open order file.

One of the important procedures of testing a company's EDP system is obtaining assurance that the program being tested is the one the company actually uses to process data. Basically there are two ways in which this can be achieved:

1. If the data processing organizational and administrative controls are adequate, the program can be requested, on a surprise basis, from the program librarian and duplicated for the auditor's control and use in processing test data. As a further measure, the auditor may request that test data previously processed with the auditor's copy of the program be processed with the client's operating program and then com-

[5] *R. M. Benjamin, "Auditing Automatic Source Recording,"* The Quarterly, *Touche, Ross, Bailey & Smart, September, 1963.*

pare the end results. This method has the added advantage of checking any computer operator intervention.

2. The auditor may request, on a surprise basis, that the operating program be left in the computer at the completion of processing operating data so that he may process his test data with it. This method has an advantage over the method above in that it usually ensures a current version of the program. In many installations and particularly in earlier stages of conversion, program changes are made frequently. These continuing program changes may make it quite difficult for the auditor to review and check all significant changes in order to be satisfied with the operations performed by the program.

As a general rule, the auditor should observe the running of the test data with the computer program. In many installations, this may not be practical because of the "grave-yard shift" scheduling of test data processing. The adequacy of the controls in the EDP department, however, should be the dictating factor here rather than the time of day, or night.

Arranging to get test data prepared and processed. In addition to obtaining master records and the client's regular processing program, the auditor must carefully design test data, obtain the necessary keypunching equipment and/or personnel, and obtain computer time from authorized personnel in order to get the test data prepared and processed, and to get the output in the desired form. Most of these arrangements are procedural and involve advanced planning with systems and computer operations people.

The design of test data is not procedural in nature but is something that the auditor will find worthy of his careful consideration. Essentially the test deck should be so designed as to limit the amount of work required of the auditor to review the results of the test. The use of special codings or distinctive names which allow invalid test transactions to be easily identified, sorted out of valid tests, and listed on separate output listings are devices which can be employed to make the auditor's job of interpreting and evaluating the test results more simple and less time consuming.

In some installations where the audit trail has been drastically altered, it is pure nonsense to argue for alternative methods of testing and evaluating the system. The only practical approach is auditing "through the computer" with the use of a well-conceived test deck. In some installations where the audit trail has not been altered with the use of EDP equipment, the "around the computer" approach may seem to be a valid alternative. But even in these electronic systems, the benefits accruing to the auditor using the "through the computer" approach appear to outweigh the problems and additional considerations involved in using such an approach. These benefits are:

1. Better knowledge of the client's system of procedures and controls —many computer installations are integrated management information systems providing operating, as well as financial, information. A review and evaluation of such a system will necessarily provide the auditor with a more complete understanding of the client's "total" system of data processing and controls than normally obtained by auditing "around the computer."

2. Better letters of recommendations—a detailed review of the computer system along with the design and use of effective tests will enable the auditor to evaluate the client's input-output controls, built-in machine controls, programed controls, and operating controls. Such an evaluation will result in more informative and constructive letters of recommendations and, hence, increased service to clients.

3. More representative tests—through the use of well-designed test decks, the auditor is able to evaluate the system's ability to handle all types of transactions, both normal and abnormal. The kind of transactions included in the test deck is limited only by the auditor's imagination, rather than by the practical limitations of time and cost involved in obtaining the same types of transactions from a sample of actual transactions. This point is emphasized by an audit manager in writing about the use of the computer in the audit testing of an automated labor recording system: ". . . The number of unusual conditions which were tested with a few simple prearranged plans would have required thousands upon thousands of transaction selections had random sampling or any other conventional testing procedures been used."[6]

4. Continuous auditing more readily achieved—one of the objectives of auditing in recent years has been the smoothing of the work flow in an annual audit examination. This has been achieved to some extent by spreading the examination between the "interim" period and the "year-end" period. Since the test deck is designed around a series of business transactions that do not change in nature from day to day, its usefulness can survive minor and perhaps major changes in the computer program. As a result, the auditor can make more frequent tests and obtain "readings" of the client's activities at different operating periods during the year without expending more time, if as much, than previously spent in testing the system.

The use of EDP equipment in no way lessens the auditor's require-

[6]Ibid., *p. 11*.

ment for evaluating the system of internal control; in my opinion, it makes the evaluation increasingly important to the audit examination and to the concept of service to the client. The auditor must recognize the importance of electronic procedures and the significance of the work performed within the EDP equipment. Accordingly, he must resist the temptation of assuming that, if the input to the machine system is adequately reviewed and controlled and the output can be checked back to source documents, he can then be unconcerned with what went on within the machine system itself.

At present, rarely will exclusive use of either of the two approaches discussed above be applicable to an electronic accounting system. The unusually large volume of data handled by EDP systems makes the "around the computer" approach impractical except in unusual circumstances. On the other hand, the inconsistency of processing found in all but the most sophisticated "total" systems renders the "through the computer" approach ineffective except in equally unusual circumstances. Experience has shown that the most effective method of auditing electronic systems will generally be some combination of these two approaches. Accordingly, the auditor can still use conventional techniques in evaluating and testing the system of internal control to some extent. But to a large extent, a fresh approach to the problem combined with the effective use of the computer is necessary.

CHAPTER

6

Management and the Computer

The Growth of CPA Management Services

The Computer's Effect on Management

ROBERT BEYER, CPA

The Growth of CPA Management Services

THE NEW TECHNOLOGICAL developments of the past twenty years—ranging from linear programing to electronic data processing—have presented a series of sharp challenges to managerial ability. All signs indicate that these technological challenges will continue at an accelerating rate.

In confronting this future, where the only certainty is change, business managers often assume that they face the perils of progress singlehanded and alone. Fortunately, although reality is challenging, it is not so harsh.

The business manager is not alone. His associates in business-oriented professions encounter many of the same problems; their experience and plans for the future may well be an important assistance to the businessman in solving tomorrow's technological problems.

This article concerns the role that one profession can be expected to play in helping the business community to solve particular kinds of current and future technological problems. It refers to the profession of certified public accounting and to problems falling within the scope of business information systems.

The typical CPA is no longer just an auditor providing an important, but sometimes disliked, service. His role has changed significantly. The CPA now provides integrated financial services to business.

Although these changes are real, too few business managers have updated their concept of the CPA. Too often they still think of him as the bookkeeper with green eyeshade, footing and ticking a ledger.

This is unfortunate. And it is not the businessmen who are responsible. If anything, one of the few services that the CPA profession has performed poorly is that of communicating its own merits to its clients. Hopefully, this article will provide a guide toward an increased understanding of today's CPA and the services that he stands ready to provide the business community.

The main propositions describing the changes taking place in public accounting and the CPA's role can be stated briefly:

1. The technological changes of the past twenty years have forced CPAs to broaden and deepen their involvement with both the managerial and the stewardship uses of financial information.

2. As a necessary corollary, CPA firms have increased their competence to provide services in auditing, taxes, and the new management services or consulting on management information systems.

3. The expansion of the CPA's interests and competence has taken place within a professional environment which has traditionally emphasized the independent role of its practitioners, ethical standards of practice, and continuity of service to its clients.

The practical result of these developments is to place the CPA in a position to offer his clients what may best be termed *integrated financial service* in all areas related to financial information systems of business.

In order to appreciate fully the meaning of these developments which lead to the concept of integrated financial service, it is desirable that we review their history, particularly their relation to the technological revolution in information systems following World War II.

Following the establishment of the Securities and Exchange Commission in the early 1930's, the CPA was gaining increased respect within the business community for his contribution as auditor or attestor of financial statements. Within the accounting profession, CPAs were busy putting the internal house in order: codifying generally accepted accounting practices, and beginning to develop solutions to some of the difficult problems of accounting principle.

Few CPAs foresaw the future challenges to be posed by an emerging information technology. The challenges concerning the CPA of the 1930's involved deepening an existing body of knowledge, not broadening its scope.

This brief picture of the CPA before World War II is, of course, not complete or fair. It is adequate for the purpose of casting the CPA in his principal function at that time: the fiduciary, stewardship, or attest function. Even today, the business community is correct in regarding the development of fairly presented financial information for reporting to third parties as the principal purpose of the CPA.

A second function of the CPA, however, has always been that of developing information flows for decision making and control purposes, of advising on the managerial use of information systems.

This consulting function of the CPA, before World War II, lacked the established respect and status of the stewardship function. Consulting on the design and use of financial information systems was based primarily on know-how and experience. Through a number of years in public acounting, CPAs were exposed to a variety of successful and unsuccessful systems; those with extra insight and skill became experts in systems consulting. Though this counsel was based on an unstructured and highly amorphous body of knowledge, a great deal of consulting about financial information systems was performed by CPAs. But precisely because it was based on a crude and unsystematized body of knowledge, the CPA's role as consultant on information systems proved his greatest challenge in the years after World War II.

Shortly after World War II, and particularly in the early 1950's, both businessmen and CPAs began to hear of startling technological developments. There was a new "scientific" approach to business variously called operations research or management science. There was a new machine for processing data called a computer.

In company with many businessmen, the CPA's initial reaction to these developments was skeptical. They sounded extremely like a recrudescence of the scientific management movement of Frederick W. Taylor in the early 1900's. In many respects these approaches to solving business problems *can* be placed in the same category with Taylor's scientific management. They both include a body of technical methods for solving problems. Both are usually external in their approach, and separate the planning of problem solving from the carrying out of solutions. Each is vulnerable to criticism if employed without proper consideration for people and organizational problems.

However, the new operations research and information processing techniques proved to be generally applicable to large classes of problems that previous technology couldn't touch. What's more, new developments continued to come from research institutions at an increasing rate.

All of this was not immediately apparent to either the CPA or the businessman. Cumulatively, however, the evidence began to mount. An astute observer would have noted the following critical developments:

1943: Abraham Wald and Columbia University's Statistical Research Group developed new methods of making decisions based on sample evidence and the beginnings of statistical decision theory.

1944: John von Neuman and Oscar Morgenstern wrote *The Theory of Games and Economic Behavior.*

1946: The University of Pennsylvania developed ENIAC, the first large-scale digital computer with a stored program.

1947-1949: Koopmans, Dantzig, Charnes, and others initiated the linear programing technique.

1951: Professors Arrow, Harris, and Marschak in *Econometricia* stimulated a renewed interest in mathematical methods of production scheduling and inventory control.

These and other developments representing logical approaches to business problems came to the attention of CPAs. At this time, the attitude of many, if not most, was similar to that of many Democrats in 1960. They didn't want to hop on the bandwagon before the results of the primaries were in. CPAs were interested in observing results as well as hearing the sales pitch.

Yet, within a very few years, the accounting profession began to exhibit serious and special interest in these new developments. What caused all of this sudden attention?

No single answer can, of course, be given. But to attempt a single answer, accountants discovered that the new technology was an *information* technology. It was apparent that an information technology would affect not only the accountant's role as information system consultant but also his role as steward of financial reporting.

Traditionally, the accounting systems of every business firm have provided the information link between events and business decisions based upon these events. In its broadest and most fruitful sense, accounting has always been an information-providing function integrated with business decision making.

If accountants and accounting were to stay in the information-providing business it was apparent that they must understand the new technology. Here were new mechanical means for manipulating and transmitting data which truly staggered the imagination. Here, too, were new logical methods of manipulating and summarizing information for decision purposes. With both were management demands for recording and developing new kinds of information. Finally, research in the area of the behavioral sciences strongly implied that new theories might drastically change established concepts of what the proper contents and channels for information flows should be.

Implications of the new technology for the fiduciary role of the CPA were not as immediately apparent as for his information system role. Here, too, however, evidence began to mount that the new methods of information manipulation and transmission were going to affect both the internal procedures and the organizational structure of firms audited by CPAs.

The impact of the new technology on the audit role of the CPA made itself most apparent in its effect on the role of the controller. In the past, a controller could, and often did, operate his shop as a separate, independent function of the business. With the advent of information technology, major firms began to install integrated processing and control systems complete with giant computers and sophisticated methods of production and inventory control. In these companies, the financial controller suddenly found that he was a new kind of controller, an information controller. (Or he found that he was not a controller at all.)

To the CPA, the inference was evident. Anything that changed the controller's function would change the CPA's audit of the controller function.

The proper course of action for the accounting profession was clear. In their auditing role, CPAs were going to deal with electronic data processing, new methods of analyzing data, and systems which placed emphasis on integrating information requirements of the firm. If the CPA were to do an adequate and intelligent job of auditing, he was faced with the necessity of mastering these new developments.

In both roles—information system consultant and auditor—the accounting profession realized that the emerging information technology presented it with a serious challenge. What has the profession done to meet this challenge? What special significance does it have for the businessman?

In order to meet the challenges posed by an expanding information technology CPAs first faced the task of expanding their competence in electronic data processing and other new management science techniques. This was a most difficult and arduous assignment. It involved mastering a new and different body of knowledge while, at the same time, keeping abreast of new developments in the traditional areas of auditing, accounting, and taxes. On first inspection the task seemed impossible. But by a variety of methods, the profession has expanded its traditional accounting skills to include the new techniques of information technology.

Management services

A first stop-gap method used by the accounting profession to expand its capabilities was transfer. Specialists in specific areas of the new technology were brought into public accounting firms. This action had the immediate effect of preventing the profession from falling behind. As a permanent solution, however, it was clearly impractical. To use specialists ethically, CPAs had to accept responsibility for their supervision and control. For the specialist's skills to be of maximum advantage to the CPA, there had to be communication and interaction between CPA and specialist; there had to be an integration of skills as applied to particular problems. Necessarily, the specialist had to learn some accounting; the accountant had to acquire some insight into the function of the specialist. The obvious need was for education.

For the mature CPA in practice, the only way to acquire new skills and competence was the laborious one of self-study. As a result, many CPAs—from local practitioners to partners of national firms—spent their evening hours studying electronic data processing, new methods of production and inventory control, linear programing or other more esoteric subjects. In frequent instances, the people developing new information and decision making techniques such as linear programing were utilized in programs of internal training. In some cases, mature practitioners were given a year's sabbatical to go back to college.

Educating those already in practice was a necessity, but it was clear that the best way to meet the long-run demands for increased competence was to obtain top-notch entrants to the profession and to continue their education after entrance. Most accounting firms stepped up the tempo of their recruiting and training programs and, to a large extent, changed their nature.

For some time now, many accounting firms have been recruiting top-notch accounting graduates and focusing their subsequent formal training on electronic data processing and management science techniques. Simultaneously, they have recruited top students trained in quantitative techniques at schools like Carnegie Tech, Stanford, Case, MIT, and Harvard, and focused their formal training on accounting. Because of this emphasis on quality and on forced interaction between disciplines, the accounting profession is currently maturing a whole new class of practitioners in both accounting and the new information technology.

By this variety of methods, the CPA profession has largely succeeded in establishing a sound base of competence in the skills and techniques of the new information technology. This is not to say that the problem is solved, that it no longer exists. The accelerating flood of new techniques—heuristic programing, information theory, PERT, Bayesian statistics, integrating research in budgetary and control systems, and new developments in behavioral science—remind one that maintaining professional competence is a continuing problem. The profession has, however, crossed the initial hurdle and brought itself up to a level where continuing developments can be integrated on an orderly basis.

During this same period of forced growth in management services competence, CPAs faced a second, necessary task of extending the depth and scope of their expertise in traditional areas of accounting.

A first problem, of course, was adjusting for the effects of information technology on the audit process. How do you audit a computer? This problem, largely technical and internal, is being largely solved by the accountant's growing competence in electronic data processing.

A second problem, technical but external, has been the need for serious and methodical re-examination and codification of accounting principles and practices applicable in the CPA's attest role. The American Institute of CPAs established the Accounting Principles Board in 1959, in response to this need. Old accounting dictums are being re-examined with the aim of clarifying and codifying those which have proved sound today and of developing those which will meet the challenges of tomorrow.

A third problem faced by the CPA has been an anticipated expansion of scope for the attest function. Looking to the future, it seems clear that this aspect of the CPA's practice will expand. Two reasons indicate the continued growth of the CPA's attest role. In our society today, we see increasing social and political pressures for businesses and businessmen to behave with more awareness of the "public interest." Also population growth and technological change presage increased complexity in business, and increased requirement for internal controls within business.

Both of these factors indicate a widening in the scope and quantity of business information communicated to outside parties. For example, the information requirements of governmental agencies can almost certainly be expected to grow—cost renegotiation, rate setting for regulated companies, compliance with regulatory statutes, status of government loan funds, and many others. Similarly, business accounting and reporting to other groups can be expected to increase. Many companies are now beginning to furnish financial data to employees, unions, and even the communities in which they are located. Even the scope of accounting reports to stockholders may well expand in the future.

Perhaps not as dramatic as the accomplishments with respect to information technology, these changes are increasing the CPA's competence even in the traditional areas of accounting.

Integrated financial services

Perhaps the most important development in which the CPA can take pride is the concept of integrated financial services.

Simply stated, the integrated financial services concept is that the CPA is in a unique position to provide all businesses with co-ordinated financial consulting services. For many years, CPAs have provided precisely this kind of service to their smaller clients. Now, CPAs stand ready to provide such integrated financial services to even the largest firm.

To demonstrate what we mean by integrated financial services and to support our contention that smaller firms have long been the beneficiary of such services by the CPA, let's consider the experience of the XYZ Company.

The XYZ Company was incorporated in the State of Illinois in 1946 by Mr. Z to produce gidgets, a new product springing from wartime research efforts. One of Mr. Z's first acts after the corporation was formed was to engage the local firm of Horowitz, Jones and Donavan as accountants. H, J and D's initial assignment was developing an accounting system for Mr. Y, who was Mr. Z's son, and was also vice president, treasurer, controller, and head bookkeeper. Since Mr. Y was not particularly adept at the intricacies of accounting, H, J and D were retained, after designing the system, to post the books and prepare periodic financial statements. And when tax time rolled around, H, J and D found themselves preparing the corporate tax return for XYZ Company and the individual returns for Mr. X, Mr. Y, and Mr. Z.

During its first few years, XYZ grew steadily as the gidget caught on with consumers. And with its growth, XYZ needed additional services from H, J and D.

First, there was the problem of Mr. Y. It became clear to H, J, and D that Mr. Y just wasn't cut out to be a treasurer and controller, an evaluation in which Mr. Y concurred. After bringing this to Z's attention, his son, Y, was shifted to sales, where Y had been spending a large part of his time anyway. H, J, and D then had the job of recruiting a new treasurer and controller. In doing so, they relinquished part of their work, hiring a young, competent man who not only could post the books and prepare financial statements, but who also had growth potential to match the company's.

At the same time, H, J, and D gained additional work by their engagement as auditors. With the business growing, H, J and D pointed out that an audit was not only a desirable control, but also a necessity. With growth of the business, XYZ family resources were no longer sufficient to provide the financing required. Shortly thereafter H, J and D helped XYZ with introductions to the banking community and with arrangements for a line of credit. As part of this help, H, J and D provided the bank with their independent opinion on the fairness of XYZ's financial condition, as set forth in its statements.

During the next few years, the XYZ Company continued to grow and H, J and D continued to assist in solving problems. Mr. X, the other son out in the shop, found he needed a simple cost system in order to control gidget manufacturing costs. Mr. Z, the father, wanted to start planning his estate. The new controller wanted to determine the feasibility of installing tabulating equipment to handle part of the accounting workload. And as XYZ increased its growth, a decision was made to raise funds for permanent expansion by sale of additional stock to the public. A large part of this task fell to H, J and D: advising in negotiations with the underwriters, filing the necessary registration statement with the SEC, and so forth.

This hypothetical story of the XYZ Company and Horowitz, Jones and Donavan could continue. But, by now, the points should be clear. For smaller clients, CPAs have long provided an integrated consulting service in financial matters, a service which has been of mutual advantage both to the client and to the CPA. Now CPAs are in a unique position to provide, and should provide, such integrated financial services to all clients.

In my opinion, the proposition that CPAs can and should provide integrated financial services to even the largest firms is soundly supported on three bases: need, competence, and professional environment.

In today's business world, the business manager needs an integrated approach to his financial information problems. This can be verified by asking any manager. There is no difficulty, however, in also finding logical support for the statement elsewhere.

First, there is the cold, hard argument of constant technological development and growing interdependence of business objectives, people, organization, and technology in an increasingly complex society. Business life, today, does not fall into neat pigeonholes that permit consideration of problems separately and independently. The businessman spends more and more of his time making sure that when he presses the button in one spot, all hell doesn't break loose in another.

Given such interdependence, the need for an integrated, co-ordinated approach to financial information problems is clear. In the future, it will become increasingly clear.

On the practical side, an integrated approach to financial problems satisfies several important needs of the manager right now. With it, the business manager is not confronted with the task of evaluating and choosing several experts to do a single job. Moreover, he is not faced with the problem of directing and co-ordinating their various efforts.

As we said earlier, financial or business information systems, broadly construed, constitute the narrowest scope in which many financial problems can be adequately considered. One approach in providing adequate problem investigation still in wide use today is for the businessman to use the services of the CPA, the EDP specialist, the operations research specialist, the systems and procedures specialist, the work measurement specialist, and so on. If he makes the right choices, provides proper direction and survives the co-ordination of these specialists' efforts, the businessman *may* end up with a satisfying solution. Practically, however, the businessman needs someone who can provide a single co-ordinated approach to his financial problems.

CPAs are competent to provide integrated financial service to business. Although the question naturally arises, "How can one man be competent to diagnose and treat all the specialized problems of business information systems?" The answer is that he can't. But a firm or community of CPAs working together can offer this competence.

Within most CPA firms today, one typically finds two kinds of competent practitioners—the generalist and the specialist. Akin to medical practice, the CPA generalist diagnoses the problem and refers the more complicated issues to a CPA specialist—in auditing, operations research, or data processing, as the case may be. Despite this similarity, there is an important, if subtle, distinction between medical and CPA practice. The CPA generalist stays with the problem. He assumes an overriding responsibility for the success of the specialist's treatment and any other programs of problem solution that may be required.

Do CPA firms today possess such specialized and generalized competence? The evidence is clear that the profession holds the necessary specialized talent to tackle almost any problem of financial information systems. The CPA's specialized competence in auditing, accounting and tax matters has long been acknowledged. Now, CPA firms are in a position to acquire new skills of information technology. Evidence suggests that perhaps the largest single concentration of management scientists and operations research personnel outside of the academic community is to be found in the public accounting profession.

Support for the generalized competence of the CPA profession is less concrete, but just as convincing. Only through exposure to a wide variety of financial information problems and to varying methods of problem solutions can mature, generalized competence develop. More than any other group of people serving business, CPAs have had this kind of exposure in working with financial information systems.

CPAs operate within a professional environment which enables them to provide integrated financial services with intangible plusses. The plusses that CPAs are able to provide in performing integrated financial services are intimately involved with the *mores* and institutions of the entire accounting profession. Without belaboring the point, the fact is that the CPA *profession* is a *profession*. Standards of ethics, independence, and competence *do exist* and *are enforced*. On an organized basis, the body of knowledge that applies to business information systems is continually being expanded both in scope and depth by members of the organized profession.

As intangible factors, different businessmen will place more or less weight on these advantages of the CPA in offering integrated financial services. Most businessmen will agree, however, about one practical advantage which stems from the professional way in which public accounting is practiced. Because of the long association which typifies relationships between CPAs and their clients, the CPA brings a wealth of particularized knowledge to any client problem that he attacks. In cold terms of efficiency, the CPA doesn't have a heavy set-up cost in tackling a problem. From the auditing process, he is familiar with the client's organization, systems, and its personnel strengths and weaknesses. He doesn't have to spend two weeks reconciling the way the company actually operates with the formal organization chart and the systems and procedures manual. Often the CPA needs to spend little time in studying and defining the problem; he may be the one who brought it to the company's attention.

I have argued above that the CPA is in a unique position to provide business with a wide range of integrated financial services, and should. At the same time, it should be made clear, however, that the integrated financial services which the CPA stands ready to provide do not include taking over the manager's job.

We have defined the new scope of the CPA interest as pertaining to financial information systems. Quite clearly, this includes areas such as organization of the financial function, financial data processing systems and procedures, procedures for evaluating investments, and inventory control procedures, as well as areas traditionally within the CPA's scope such as financial reporting. But with very little stretching, the same definition can include such diverse areas and functions as plant layout, engineering studies, or what have you. Every area of business is, to some extent, involved with financial information systems.

From this point of view, it is difficult, if not impossible, to define the CPA's scope precisely. Moreover, in view of the fact that the needs of business will change over time, it is doubtful if it would be desirable to attempt to define the proper areas for CPA practice once and for all.

In spite of these ambiguities in theoretically defining the range of CPA practice, there are some practical limitations which tend to delimit scope at any given time. The first of these, enforced both by the AICPA and clients, is that when the CPA consults, he must be competent to consult. You can't consult on data processing systems if you don't know a keypunch from a sorter.

The second limitation generally observed by the profession is that CPAs shouldn't consult in a non-consultable area. Professional consulting, as distinguished from personal advice, is properly performed only in relation to a structured body of knowledge, where it is possible to review consulting advice on an objective basis. Objective review implies review by competent peers who can draw on a common body of ascertainable knowledge to reach similar conclusions. Straightforward interpretation of this rule limits the CPA's participation in fringe areas such as marketing, where it is doubtful that a structured body of knowledge exists.

THOMAS L. WHISLER

The Computer's Effect on Management

IN MY SCHOOL—the Graduate School of Business at the University of Chicago—those of us on the faculty have recently had the rug pulled from under us. This "rug" is the familiar fabric of knowledge which has structured research and training for some years in our professional school. It was yanked by a technological change, the chief engine of which is the computer.

Consequently, we are changing our curriculum substantially, even though we are uncertain about how best to change it. We are altering our research techniques, but are still not sure about the virtues of such alterations. Many of us find that well-established ways of defining and solving problems—ways that we taught our students—are being superseded by new and strange ones. More than strange, these ideas often are incomprehensible to many of us, especially to those of us showing some gray in our hair. Some of us are suspicious, resentful, and—if the truth were known—afraid. We are the reluctant ones.

Others of us are confident—perhaps occasionally arrogant—in our new knowledge and techniques. We have no question of their power to sweep aside old approaches. We are the impatient ones.

Some of us stand on the sidelines, detached and amused, pointing out that the development of the computer is no different from the invention of the steam engine—or the wheel—or fire—and, thus, that it is just one more of a long line of blessings. We are the economists.

All of us—those afraid of obsolescence, those eager to innovate, and those above it all—must sit down together and evaluate the new technology and its implications for us. We have to go further and jointly reach decisions on actions affecting us as a group and as individuals. For, as a school, we are under pressure to lead, to show the way. And we have competition—good competition.

But I don't want to make my case simply on the basis of turmoil in the academic world. It happens that our school is closely tied to the main arena of action—enterprise management—and so are most CPAs.

My chief interest for the last five years has been to watch the effect of information technology—computers and management science—on managers: on the way they do their jobs, on the organization structure within which they work, and on the skills they need. I would like to enumerate these impacts and forecast their implications for management of the future and for all of us.

Perhaps I can do this forecasting better, or at least more vaguely and safely, if I broaden the picture just a bit and discuss two areas—first, certain new discoveries of importance to management; and second, certain social attitudes and behaviors, sometimes damping, sometimes accentuating, the effects of these discoveries on management.

Within the last decade we have seen three particularly important new developments in the state of human knowledge which have resulted in new technologies and new ways of doing things in management. One is the knowledge of how to use electronic computers in solving operating problems in business. The second is the development and application of management science or operations research—a series of practical applications of mathematical and statistical techniques. The third—and one that is just getting on its feet—is the development of real insight into the nature and operation of organizations—organization theory as it is called. Many of us are convinced that the computer and operations research applications will bring about big changes in the structure of organizations. Better understanding of organization theory may aid the manager in effectively adapting his organization to these technological impacts.

While factory automation has already generated some large-scale problems of change, we haven't really begun to feel the full impact of the new discoveries in computer technology and management science. The problems coming up will be concentrated at the managerial level. They will evolve from changes induced in organizations by the combination of computers and management science—by information technology. They are the problems of the 1960's and 1970's.

For the past five years I have been watching and studying organizations that have been learning how to adapt to this new technology. The purpose of this watching has been to look for evidence that organizations and executives really do change, and to learn in what ways. The watch is not over. The case is still open.

But some armchair predictions about the nature of management in the 1980's are already in the public domain and have been rather widely discussed. Here is how they seem to be standing up as more and more evidence comes in:

Prediction number one was that information technology would have the effect of flattening the organization structure. Evidence that we have gathered seems to support this. The most spectacular examples lie in the military, where cost considerations are secondary to national security. A clear case is NORAD (the North American Defense Command), set up to protect this continent from outside attack. Introduction into NORAD of the SAGE system—an elaborate control system incorporating radar, radio, and (most important) batteries of computers—has changed the management organization structure, eliminating one level. Pre-SAGE there were five levels; post-SAGE there are four. In effect, one of the middle levels was eliminated. We have found the same shrinkage effect in two business organizations on a less heroic, more cautious, scale. In one case the number of managerial positions was reduced by more than 30 per cent over a two-year period in those areas where computer systems were applied.

This flattening of the structure is inevitably accompanied by recombination of parts of former positions into new bundles of responsibility—new positions. It isn't really a case of a layer of management being removed whole and intact. Rather, the computer takes over some parts of various positions. Subsequent consolidation produces new ones. In one company, as a consequence of this process, credit management, warehouse management, and sales responsibilities have been combined under a number of distribution managers. In another, the result was the consolidation of two vice presidential jobs—those of vice president of production and vice president of merchandising. The SAGE reorganization actually eliminated only about 50 per cent of the headquarters groups at the level affected. The others were recombined with still different groups. As you might expect, when the smoke of these reorganizations cleared away, the managers who survived and thrived were those who early saw the advantages of the new systems and new organizations. Ask not for whom the bell tolled.

Another prediction, made five years ago, was that information technology would recentralize control in organizations. That contention has provoked strong reaction—some very respectable management consultants arguing that the prediction was exactly backward; that further decentralization will result from computer applications. But in the company that experienced the 30 per cent shrinkage in managerial positions, production planning, accounting, and purchasing are now accomplished centrally for three scattered facilities, each of which formerly was its own boss. And NORAD again furnishes clear-cut evidence. At the same time that the command structure shrank from five to four levels, the tactical decision making level for control of interceptor weapons moved from the lowest level to what formerly was the third level from the bottom. We have found other examples: consolidation of grain buying in large milling firms, of space selling in computerized airline reservations systems, and of the total supply and inventory function in the Defense Department. And surely everyone is aware of the spectacular increase in power that the new technology has given to the Secretary of Defense.

Observed changes, then, support the predictions of the flatter organization and the recentralization of control. But on a third prediction I now have some doubts. The prediction was that information technology would routinize many of the middle management positions in the reorganized structure. There are two reasons to be uneasy about this prediction. In the first place, it is too soon in most organizations to focus the picture properly. How can you tell if jobs will be routine if people are still cutting, fitting, and trying to get the "new" jobs effectively designed?

More important, the prediction was based upon an analysis of the managerial job which may not have been too well thought out. It seems to me, at this point at least, that the important effect of the new technology is to make a man-machine system out of what was formerly an all-human system—the managerial group. Much of the manager's job today is what might be called computation—evaluating information, weighing alternatives, making choices. Much of his job is simply communication with customers, fellow managers, subordinates and (now) the computer. The computer's comparative advantage lies in computation. The communication part of the manager's job thus should become proportionately more important, but it does not seem to me that this in any way means that the job will become more routine.

Just what the job does become or will become is not clear. One manager in the new computerized distribution system which I mentioned earlier said that his job had changed from one of meeting crises day after day ("putting out fires" as it is called) to one in which he has opportunity for the first time to know his customers and their needs, and opportunity to give adequate attention to selection and development of staff. On the other hand, consider this comment by an Air Force officer on the effects of the SAGE application:

> One of the queerest observations that I have made concerns this mass of engineers, technicians, machine operators, and operations people milling around and working almost unaware that anyone else exists. That is to say, there doesn't seem to be any interaction between the individuals. All of the interaction seems to be with the electronic system. This is quite a change from the old squadron where communication and interaction between individuals were a must to accomplish the mission. In addition, it carried over into the social environment and it developed friendships, cliques, and competitions. This leads to a question about the importance of tradition, regulations, lines of authority, and morale. These have always been an integral part of military organizations, but, in this instance, they seem to be relatively unimportant. I believe that the computer is the cohesive element in these up-and-coming systems, and they simply set the pace and individuals blindly follow. It's like a fire into which everyone is throwing everything he owns for fear that, should it go out, they will all die of the cold.

So much for the 1980's revisited. At least so much for certain predictions of how the manager's world will have been affected by technological change by that time. Some difficult and fascinating problems of transition face management between now and then. Let me list some of the more important ones:

1. Managers will be displaced, will need retraining, relocation.
2. Organization structures must be disassembled and rearranged into forms not yet obvious.
3. An appropriate home in the organization for the new technology and technologists must be found. Meanwhile, power struggles in the executive suite will be frequent.
4. Some kind of practical economic guidelines must be evolved to tell us where the new technology should be applied and how far to go with it. Elementary economics tells us, of course, that as computers get cheaper and more sophisticated, relative to managers, we begin to substitute the one for the other. But where to substitute and how much are the big questions.
5. The top executive in every organization must develop an awareness of the full impact of this new technology and of the important role he must play in its introduction—an awareness sadly lacking today.
6. All members of the organization must adapt to a new technique and rhythm of planning.

Time doesn't permit examining each of these problems in detail. Some, like the displacement matter, are not new to us, except that managers instead of factory hands are now the DP's. But some problems are new. Let me comment briefly on the last two I mentioned.

At the present time many chief executives tend to apply the familiar rule of delegation to the introduction of the computer. They okay its purchase and delegate responsibility for its effective application to some subordinate. Often this subordinate is the controller, the organization's number man, who is usually Johnny-on-the-spot with the new number machine. Regardless of who the subordinate is, when he discovers the really important things that can be done with the computer, and then does them, he begins to tinker with organization structure, managerial jobs and fundamental organization processes. At this point fearful crises can develop (and we have watched some). These crises rage until the top executive grasps the true nature of this new technology and assumes his unavoidable responsibility for its introduction and application.

On the last point, planning rhythm changes in two ways. The computer permits much more frequent and accurate planning of a tactical sort—the kind where, for example, unanticipated changes in sales require reprograming of production, purchasing, and labor force management. Planning periods can be and are shortened, with the computer rapidly computing proper adaptations to new conditions. In one very large corporation this sort of planning was done quarterly before the computer, biweekly after.

Long-range strategic planning, on the other hand, can be extended further into the future through use of appropriate simulation techniques—and the computer. The "corporate laboratory," as one company calls it, permits testing of the probable effects of major decisions over long periods of time under a variety of assumed conditions.

In both kinds of planning, managers become more the question-askers; computers, the question-answerers. The planning technique becomes that of creative interrogation.

The problems of transition engross our attention at the moment. Information technology, like technological change in the factory, has important effects upon people. But for the first time—in industrial history at least—those who will be most affected by the change are also those who are responsible for initiating and planning it. Managers, just like professors, in their efforts to make use of this new and powerful technology, must be able in an objective and deliberate fashion to consider the impact upon themselves, and to reorganize themselves as necessary. Understandably, those who see their own positions being threatened by a change will be reluctant to adopt it. Resistance to change in the factory or office is so well known that we assume that it is peculiar to workmen and clerks. My observation is that this resistance is characteristic of all men, or at least of that portion of mankind which includes both executives and professors.

I am an optimist. I believe that as social scientists learn more and more about the structure and functioning of organizations, this knowledge will be communicated to and discussed by managers, and that we will find problems of reorganization—in the business firm, the hospital, the government agency—being discussed with less panic and confusion, and being handled with more sophistication than at present.

The new discoveries—the technological changes—dominate our interest and attention today. But we need to evaluate technology in the context of certain environmental forces working to shape the executive role.

In my judgment, three characteristics of American society are significant here. Two of them are simply long-term characteristics with cumulative effects; the third is a more recent development.

One factor is the pervasive long-time belief in the importance of education. Starting over a century ago with the introduction of free public education, Americans have always spent a substantial portion of the national income on educating their children and themselves. Critics of the educational system—and the woods are full of them—usually argue that too little education is given, or that it is given to too few, or that it is of the wrong kind. So far as I know, no one, except for a few real primitives, stands up today to urge that America is threatened with overeducation.

A second long-term characteristic of American society that seems important to me in the context of this discussion is the mobility and restlessness of our citizens. The American speaks nostalgically of the old family homestead, but apparently has little intention of turning his own house into one. He picks up and leaves constantly. It is not only the young corporation trainee, but others—tradesmen, blue collar workers, clerical workers, school teachers and the rest—who move from house to house and from region to region. For most of us home is where you hang your hat and we change hangers frequently.

A third, and clearly newer, characteristic of our society is the belief in the value of research and science. The prestige of the scientist has never been higher. The amount of money currently being poured into research and development by private industry and by government is enormous.

In terms of their impact on tomorrow's management, these three characteristics of our society seem to me to presage several things. One is that the organization of the future will have more and more individuals with training of a professional level—simply because more of our labor force will have such training. Some evidence of this development has already shown itself. Between 1950 and 1960, professional and technical workers in the labor force increased by 47 per cent, the greatest growth of any group. Those employed as proprietors and managers increased by 7 per cent, only about half the increase for occupations as a whole.

The new management breed

This rapid growth in the number of professionals should influence the nature of the organization of the future. Professional people are mobile. They are accustomed to dealing with a rich variety of problems and developing individual approaches to them. They tend to be independent in attitude and outlook. As increasing numbers of such people move into the management group, we must expect a change in the concept of effective organization. We can anticipate less emphasis on loyalty to the organization, since the professional career tends to thread through a number of organizations as a matter of course. Risking oversimplification, we can say that the professional is primarily interested in a constellation of professional problems—only secondarily in the survival and growth of a particular organization. The organization must develop ways of capturing this professional's contribution without trying to capture him personally. The obvious way to do this is to provide him with challenging problems and the freedom to solve them. But we don't yet know how to do this.

We should also anticipate pressure to decentralize the structure of control within the typical business firm. Professionals prefer to work more or less as equals with one another. In addition, we might expect a trend toward looser definition of jobs and a looser coupling of jobs than is typical today. The advertising agency is perhaps the closest contemporary example of this kind of loose organization. These changes will bring greater flexibility to the organization but, of course, flexibility brings with it its own problems. The decentralization and flexibility that the professional brings may well act as a damper on the computer's centralizing effect.

The value attached to research influences countless decisions to put resources into research—research carried out in private organizations and public. Organization structures increasingly reflect this flow of resources into research in two ways. First, many grow new units internally which specialize in research of one kind or another. These units, staffed largely with professionals, generate (hopefully) new ideas for products, for operations and methods, and for winning customers. Unfortunately, they also generate problems of co-ordination, co-operation, and understanding within the organization. Whether it is better to keep the long-haired scientific and professional types in isolation wards or to try somehow to bring them into the managerial structure is a problem still unresolved. As research becomes a larger and larger budget item, resolution of the problem becomes critical. Here is a challenge for organization designers.

The great emphasis on research has another sort of impact on organizations. The best illustration of this impact is information technology itself. This technology is the joint product of scholars and researchers in universities, government agencies and private organizations. Its effects, as we have noted, are profound and pervasive. But it is only one of the major contemporary payoffs of our research efforts. Another is the development of new energy sources. And there are still others. The point is that large diversion of resources into research inevitably results in large changes, technical and social, later on. And if you hold the input button down long enough, the changes can be formidable. Look at what seventy or eighty years of research have done to the organizational structures of agricultural production units—the farms. And that change has been somewhat painful. *Organizations deliberately designed not only to generate change but to be able to change themselves will be the best bets to survive in a research-directed society.* This design idea—this design requirement—is so new, so little explored, that no examples outside the social science laboratory come to mind.

Breakdown of traditional hierarchy

Perhaps the preceding comments have seemed to lead off into a number of directions and to make the managerial world of the 1980's sound like an appallingly complex one. There are certainly contradictory forces at work, but I think we can see a few major patterns emerging. First, we should clearly expect the organization twenty years from now to look less and less like a military hierarchy and more and more like a partnership of professionals. This means that the authority structure of today's organization will tend to become more decentralized in the future. The interim impact of the computer in centralizing control is clear. But the functions of manager and of machine will become increasingly differentiated, permitting, in the long-run, decentralization of the creative managerial functions which are retained by men, and centralization of the operating functions given to the machine.

Second, the growing number of professional specialists will bring with them changes in managerial attitudes and behavior. We can expect less emphasis on organizational loyalty and greater individual mobility. We can expect demands for greater independence of individual action in the organization and strong individual interest in solving a wide range of problems—pressure for job enlargement at the managerial level.

Third, the skill and knowledge needs of managers will grow rapidly, especially in the technology of computers, in the use of mathematics and statistics to solve managerial problems, in organization theory, in economics and anthropology.

Obviously, no one man can know all there is to know today in large organizations. It will be even less possible for him to be competent in the increased range of knowledge needed in tomorrow's organization. The breakdown of the traditional hierarchy with a single chief would seem to be inevitable simply because of this growth of knowledge. The use of multiple chiefs, or committee top management, is becoming increasingly popular in United States corporations and seems to me to be the first step toward the kind of general partnership arrangement into which management will move in the next few decades. The tide may already be running strong this way. A Chicago executive I know, getting his first real exposure to the multiple boss arrangement, said to his secretary as he left for lunch, "If my boss calls, be sure to get his name."

I would expect, however, some complications and difficulties to appear as part of the long-run trend toward centralization. One of the difficult and unfortunate by-products of decentralizing may be the problem of maintaining the entrepreneurial spirit and ability in the organization. On the whole, centralized autocratic organizations seem to have a better record in entrepreneurship—in creating new functions and new organizations—than do the collegial decentralized organizations.

In our graduate school of business we are engaged in continual dialogue about the best way to educate young men–and those not so young–in preparing them for management tomorrow. Probably the only thing we completely agree on so far is that the faster our stock of knowledge grows, the more urgent it is that practicing managers frequently update their knowledge through formal training. We are becoming increasingly convinced that managerial training must continue throughout the career of the executive.

Let me remind you at this point that business executives are not the only ones threatened with obsolescence. All professional people are similarly threatened—the lawyers, the doctors and the professional accountants. As information technology whisks the carpet off the floor of the executive suite, *you* will tumble along with the men in the gray flannel suits.

You taught them how important it was to scrutinize certain pieces of paper. They are painfully and slowly learning that until they give up that paper they are wasting the money they spend on computers. This relinquishment of paper takes a special kind of courage.

You convinced these executives that certain periodicities in corporate life are almost sacred—the annual closing, the quarterly statement, the weekly this and the semiannual that. The computer doesn't need your traditional fiscal tide tables. As managers gradually become aware of this, will you have new oracles ready for them?

CHAPTER

7

Management Becomes Scientific

Behind the Scientific Approach to Management

Decision Making—Art or Science?

CLARK SLOAT, CPA AND ARTHUR B. TOAN, JR., CPA

Behind the Scientific Approach to Management

OVER THE PAST FEW YEARS, hundreds of business executives have, according to their natures, blood pressure and job security, either suffered through or exulted in playing the "management game." Basically, the management game pits several teams of executives against each other through the medium of a computer. Given certain basic assumptions; size of market, resources available, number of competitors, etc., each team makes certain operating decisions for its hypothetical company. These decisions are fed into the computer, digested and weighed against the operating decisions of the competing teams. The computer then determines just how much each company has improved or worsened its financial strength and feeds the results back to the teams so that they can make their plans for the succeeding quarter. The management game is a simulation of a competitive business situation just as military maneuvers are a simulation of a shooting war.

You, perhaps, are one of the increasingly large number of executives who have subjected themselves to the emotion-shattering experience called the management game. How would you describe it? After eliminating the unprintable expressions, phrases like the following would probably predominate: playing the management game; practicing decision making; matching wits with your competitors; choosing business strategies.

These expressions emphasize that the practice of management is an art based upon a combination of knowledge and experience and a feeling for the way human beings act in typical business situations.

You may not believe this, but another group—admittedly a different kind of group—would probably describe this experience in quite a different manner—as, for example: understanding the model; numerically evaluating alternative choices; computing the odds; gaming against a competitive model.

Those individuals would be stressing the fact that scientific methods of analysis and evaluation can play a very important role in making management more effective.

The extremists in one camp would claim that management is pure art; the extremists in the other, that it can be made virtually a science. The moderates, who in our opinion are right, would proclaim that the practice of business management (like the practice of medicine) is a combination of both art and science in which the two mix in varying proportions according to the circumstances of the case.

Perhaps, before proceeding much further, we should properly define one word which has already been used—"model," for the concept of "model" lies at the heart of the scientific approach to business management. A model is precisely what you might think it would be—a representation of reality. A model can assume a variety of forms. It can be physical. Bergdorf Goodman Co., for example, employs models in the limited sense of the word so as to provide madam with a somewhat idealistic representation of what the decision to buy a certain dress might do for her. A company which builds a pilot plant to see how a production process would work is also building a model.

Models need not be physical. As a matter of fact, there are far more models which are not physical than there are of the other type. A balance sheet is a model—a representation of a condition in monetary terms. H_2O is a model representing a molecular relationship of the two elements which form water. Another model is "length times width equals area"—a model which is expressed in words. It is, of course, still a model when it is expressed as the kind of mathematical formula which we learned in grammar school:

$$(L \times W = A)$$

It is possible that some clever individual could build a physical representation of your business, although this would not be easy to do. It is much easier to prepare a model of a business or most parts of a business in nonphysical terms—in terms, actually, of mathematical formulas.

A management game (which is intended to represent a hypothetical business) is based on a formula or a series of formulas. This can be proven by the mere fact that the game can be run on a digital computer. We would be disclosing no secrets by citing a few of these formulas:

$$C_o + C_r - C_e = C_1$$

(Cash on hand at beginning of game plus cash received less cash expended equals cash on hand at end of period one.)

$$P = S - G - E$$

(Profit equals sales less cost of goods sold less expenses.)

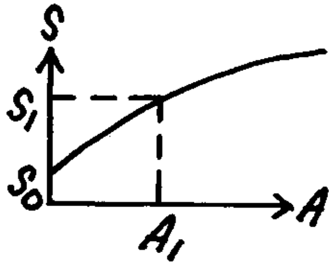
You may bridle a bit about dignifying or confusing these well-known relationships in this manner. You should not. Formulas are the language of the mathematician and the scientist and they have every bit as much right to their language as you do to yours or, perhaps more appropriately, as your secretary does to her particular brand of shorthand.

Formulas, of course, can express ideas and relationships which are far more complicated than the simple, straightforward linear relationships I have just illustrated. It is a well-known physical fact, for example, that the octane rating of a gasoline can be raised by the addition of tetraethyl lead. But it is also true that the rate of improvement in the octane rating decreases with increasing lead concentration—that is, octane rating does not increase linearly with lead concentration. The same thing must be true about advertising. There must be some change, maybe several changes, in the rate at which advertising produces an increase in sales. One of our more picturesque figures of speech—"skimming off the cream"—indicates just how frequently this changing relationship does occur. The mathematician or the scientist would also have a shorthand way of expressing this more complicated idea. In the particular hypothetical case represented by the graph, it might be something like the illustration shown on page 212.

An article written by the developers of one management game provided the incidental intelligence that, at one stage in its development, the formula shown at the bottom of page 213 determined the unit cost of production.

Both are more complex ideas and formulas—but obviously nowhere near the limits of either. Stated another way, the mathematical formulas keep pace with the complexity of the idea.

We could go on and on and ultimately build up a model which compared at least roughly with the formulas on which the game is based. We could do this by the experience gained in observing what happened in this game and by drawing upon other experiences within



$$S = \sqrt{S_0^2 + \frac{S_1^2 - S_0^2}{A_1} A}$$

(Advertising increases sales but at a decreasing rate.)

and without the business world which we feel are comparable. If we could do the same thing for some part of a particular company or industry and/or the business world in general we would then have a mathematical representation of a real situation.

Then, all we would have to do would be to replace the letters in the formulas with some numbers and we could tell what would happen under any set of conditions. As you have undoubtedly discovered already, this would be an easy thing to do (1) if you could only figure out why the business acted the way it did in the past, and (2) if you could only feel pretty certain that the business or model would act the same way in the future.

There are several troubles: (1) the relationships both within and without the company are exceedingly complex; (2) the information about what actually happened is in large part inaccurate or incomplete; and (3) there is real uncertainty about the actions which will be taken by yourself and others in the future and the nature of the social, political, economic, and physical environments at the time these actions are taken.

Yet, anyone who manages in anything other than a capricious manner must attempt to work out the best estimate he can as to what these facts and relationships were, are, and will be. Otherwise he is guessing, hunching and hoping—"flying by the seat of his pants." What the moderate claims he can help management do is not to take over management but rather by the application of some of the techniques of the scientific method to help provide: (1) a deeper insight into the nature of business relationships, (2) a better means of assigning values to many of these relationships, and (3) a better means of reducing or at least taking explicit cognizance of the uncertainty which surrounds many business plans and actions. The use of the words "deeper" and "better" was quite deliberate, for the moderate makes no claims that he has either the ultimate approach or the ultimate solution.

There are a number of techniques employed by the scientific approach—far more than can be covered in this paper in sufficient detail to provide any real knowledge of them.

Linear programing

Let us, therefore, skim through a number of techniques. First, let us take a somewhat limited although definitely "real-life" problem and show how one mathematical technique called linear programing might be used. It is a very common problem—what is the best way to distribute a product from factories to dealers? If it is common, it is also complex.

The scientific approach would say that you must take into account at least the following: (1) the standard of service you desire to render your dealers and indirectly your ultimate customers; (2) production costs; (3) transportation costs; (4) inventory carrying costs; (5) data handling costs.

To simplify matters, let us consider only the second and the third of these.

Let us use some figures, shown in Exhibit I, page 214.

The problem is to determine: (1) how much each plant should produce, and (2) which dealer should be supplied from which plant in order to minimize the sum of production cost and transportation cost.

$$U = C_5 + \frac{C_6 + C_7 M}{1 + C_8 m} + \max\left\{\frac{C_9}{1 + C_{10} r}, C_{11}\right\} + \frac{C_{12}}{M}$$

Formula Used In Management Game To Determine Unit Cost Of Production

This is a simple version of the way this problem would appear in most business situations because we have intentionally made it so. Nevertheless, the problem stated is not an easy one. If you attempt to solve it using merely business judgment you will encounter quite a few conflicts. When you try to take advantage of the best freight rates, you will find that you are not loading some of the plants sufficiently to take advantage of their lower cost of production. When you try to take advantage of the full capacity of the low-cost plants, you will find that freight costs are out of line. Further, even when you do the best job of allocating that you know how to do, you will have no specific idea how much better a solution is actually possible.

In any situation of this nature, where you are caught between the devil and the deep blue sea, mathematical methods become valuable in selecting the best, or optimum, course of action.

Let's take a look at how this problem can be solved. Exhibit II, on page 215, shows the formula used.

Exhibit I

Warehouse	Market (10# Units)	Transportation Costs From Plants 1	2	3	4	5
A	50M	$.250	$.375	$.375	$.500	$.175
B	250	.175	.250	.325	.450	.140
C	75	.100	.225	.275	.425	.175
D	25	.140	.220	.225	.425	.190
E	30	.195	.190	.150	.400	.220
F	40	.325	.210	.175	.235	.315
G	50	.350	.190	.150	.210	.325
H	200	.290	.190	.220	.125	.240
I	60	.295	.175	.190	.110	.250
J	40	.220	.090	.210	.150	.215
K	20	.450	.200	.175	.175	.340
L	150	.175	.350	.275	.325	.175
M	70	.200	.350	.300	.325	.200
N	10	.225	.375	.325	.350	.225
	1,070M					
Productive Capacity	1,300M	250M	300M	250M	300M	200M
Unit Prod'n Cost (10# Units)		$10.80	$10.75	$10.65	$10.80	$10.75

As you can see, the development of this formula does not appear too formidable when it is broken down into its elements and the relationships of the various factors are explained in the words we normally use in our conversations. They are frightening, however, to the non-

Exhibit II

FORMAL MATHEMATICAL STATEMENT OF PROBLEM

Let

Xij = no. of units of product manufactured in plant i (i = 1,2 ..... 5) and shipped to market j (j = 1,2 ..... 14)

Cij = unit cost of manufacturing product at plant i and shipping to market j

then

CijXij = cost of manufacturing Xij units of product at plant i and shipping this quantity to market j

so that the total manufacturing plus shipping cost to be minimized is given by

$$C = \sum_{i=1}^{5} \sum_{j=1}^{14} C_{ij}X_{ij}$$

Since the market requirements are limited and the plant capacities are likewise limited, it is necessary to include these restrictions in the solution. Thus, let

Rj = no. of units required by market j (j = 1,2 ..... 14)

and

Ai = no. of units capable of being produced at plant i (i = 1,2 ..... 5) then the Xij which minimize the above cost function must satisfy the following restrictions:

$$\sum_{i=1}^{5} X_{ij} = R_j \quad (j = 1,2 \ldots\ldots 14)$$

$$\sum_{j=1}^{14} X_{ij} \leq A_i \quad (i = 1,2 \ldots\ldots 5)$$

and finally since negative shipments are not meaningful here we must have that

$$X_{ij} \geq 0 \text{ for all i and j}$$

For the benefit of those who may have forgotten the meaning of some of the mathematical symbols used above:

Σ is a *summation* sign, the limits of the summation indicated by the numbers written above and below the sign. Thus $\sum_{i=1}^{5} X_i$ denotes the sum X_1, X_2, X_3, X_4, X_5, the *index* ranging from 1 to 5.

Finally, the symbol ≤ indicates that the left hand side is smaller than or equal to the right hand side; the symbol ≥ that the left hand side is greater than or equal to the right hand side.

mathematician when merely presented as a body of symbols. However, through the use of these formulas and with the aid of a large-scale computer, it was possible to solve these rather intricate formulas in less than five minutes, of which fewer than five seconds were required for the actual computing. The answer to the problem is shown in Exhibit III, below.

You can do rather well with a pencil and paper with this extremely simple problem. How long, however, would it have taken you to arrive at the optimum answer and how would you have known when you had arrived there?

The optimum solution to this problem was secured through the use

Exhibit III

OPTIMUM (MINIMUM COST) SOLUTION

		Plants				
Warehouse	**Req'ments**	**1**	**2**	**3**	**4**	**5**
Alternative I:						
A	50,000					50,000
B	250,000	30,000	70,000			150,000
C	75,000	75,000				
D	25,000			25,000		
E	30,000			30,000		
F	40,000			40,000		
G	50,000			50,000		
H	200,000				200,000	
I	60,000				60,000	
J	40,000		40,000			
K	20,000			20,000		
L	150,000	145,000		5,000		
M	70,000			70,000		
N	10,000			10,000		
Plant capacities		250,000	300,000	250,000	300,000	200,000
Unused plant capacity		0	190,000	0	40,000	0
Alternative II:						
L		(70,000)		70,000		
M		70,000		(70,000)		
Alternative III:						
L		(10,000)		10,000		
N		10,000		(10,000)		

Total production cost	=	$11,503,000
Total transportation cost	=	174,325
Total cost	=	$11,677,325

of one of the mathematical techniques known as "linear programing." This is a method used to produce the best solution to a problem where the relationships fall into a straight line—i.e., are linear—where total costs vary directly with volume, for example. In the foregoing problem, cost was assumed to vary directly with volume—it was a problem merely of selecting the best out of a number of courses of action. This relationship doesn't always hold true (in real life, it would almost surely not be true even in this case)—so linear programing doesn't solve all problems. In those cases, different types and forms of mathematics are needed.

Of particular significance in this problem is the fact that the linear programing solution provides two additional optimum programs, i.e., three solutions were obtained, each of which yields a minimum cost schedule. This information could be very useful to management since a particular one of the three solutions might be preferable on some basis other than minimum cost. Perhaps some more or less intangible factors relating to the personalities of the plant managers, for example, might suggest the desirability of choosing one alternate best solution over the others.

An interesting and perhaps not self-evident fact is that one of the major benefits to be obtained from this approach is the determination of the best course of action to be followed when things go wrong—i.e., in a time of crisis. Some companies which have made investigations of what actually happened when a plant, part of a plant or something else became inoperable have concluded quite definitely that they make their big mistakes—and their expensive ones, too—when the unexpected happens. The advantages of the combination of mathematical formulas and computer are that alternative methods can be ascertained rather quickly in an unemotional manner, with a high degree of assurance that the suggested solution is a good one in light of the new conditions.

Probability and statistics

If we had the space, we could discuss many additional interesting problems using these and other techniques. It would appear more productive, however, to explore a few ideas about probability and statistics since they are extremely important tools in decision making.

In the illustration of how products were to be allocated among factories, certain figures were used for expected sales, productive capacity, transportation costs, etc. For purposes of the illustration, they were considered to represent the future. Would they? We must confess, we are uncertain. To admit we are uncertain is a start but unfortunately it helps little, for we are certain or uncertain in very different ways and different degrees about these items.

Take the figures for productive capacity, for example. How likely is it that the productive capacity will be 1,300,000 units? You might say that, barring strikes and major catastrophes, you are fairly certain that this capacity can be reached, but there is a chance that it would not. If you were pressed long enough and hard enough you might end up with a statement like this:

ESTIMATED PRODUCTIVE CAPACITY	PROBABLE FREQUENCY OF OCCURRENCE
1,450,000 — 1,600,000	1%
1,350,000 — 1,450,000	3
1,250,000 — 1,350,000	90
1,150,000 — 1,250,000	3
1,050,000 — 1,150,000	2
Less than 1,050,000	1
	100%

Let us now look at sales. In most "real-life" situations, you would almost certainly not be willing to rate your ability to estimate total sales (let alone sales by individual areas) with anything like that degree of precision. Something like this might therefore result:

ESTIMATED ERROR	PROBABLE FREQUENCY OF OCCURRENCE
Over by + 30 to + 50%	5%
+ 10 to + 30%	10
— 10 to + 10%	50
— 30 to — 10%	25
— 50 to — 30%	10
	100%

These are probabilities related to our ideas of future events of a somewhat general type. Other probabilities can be developed which are more specific:

1. What is the probable traffic pattern over the George Washington Bridge throughout a day?

2. What is the probable number of customers desiring service in a bank during a Friday peak?

3. What is the probable number of mechanics' requests for tools at a tool crib during various periods of the day?

4. What is the chance that we will be out of stock if we carry a given minimum quantity of a particular item of inventory?

5. What is the probable number of buses which will be out of service on a given day because of mechanical breakdowns, etc.?

What is the significance of probability data? Just this: It helps the businessman to take specific cognizance of the degree to which uncertainty exists and thus to plot alternative strategies or a single strategy taking these facts into consideration.

A businessman in the illustration previously cited would be quite likely to consider that a capacity of 1,300,000 units would be available in the next period since this will be true 94 times out of 100 and because in 97 times out of 100 available capacity would equal or exceed 90 per cent of 1,300,000—and could presumably, therefore, be brought up to 100 per cent either by depleting inventories, working overtime, etc. He would therefore, in the absence of specific information to the contrary, be inclined to make his plans on the assumption that the capacity would be available.

Sales estimates are quite a different matter. In 35 per cent of the cases, sales would fall below expectations by from 10 to 50 per cent. Much less "certainty." This would probably lead the businessman to adopt a more cautious policy in producing and stocking items and also to incur the expense of constantly revising his forward sales estimates. More cautious, yes; but how much more cautious? It would depend on the potential loss from overstocking, the potential loss of sales resulting from understocking, the increased or marginal costs of producing additional quantities on an accelerated or emergency basis, etc.

Once again, with the limits of our ability to obtain data, all this can be expressed mathematically and thus an optimum strategy can be developed taking cognizance of the probability that a given set of conditions will occur a given number of times. Statistics thus can help to cope with the risks of uncertainty.

There is one additional fact about statistics which might be mentioned before we leave this unsophisticated and definitely incomplete discussion of them. Many forms of statistics are fairly cold-blooded; they search for normal and abnormal patterns of behavior and often attempt to ascribe them to causes without, you might say, getting excited about it. Statistics is full of words like "random," "stratification," "confidence level," "standard deviation," etc. The way you use statistics may be very warm-blooded indeed, but basically the process itself is not.

Theory of games

This last statment is in fairly sharp contrast with the next subject—game theory—which also involves mathematical statistics. It is a "theory" which states the quite obvious fact that in a situation in which two or more forces are competing for the same goal, the strategy employed by the opposing forces is itself of vital importance in selecting the best strategy to follow. This is just as true whether it be in a game of tennis or in war where each force directly opposes the other as it is when the opponents compete for some third party—such as the customer and his money. Game theory is at the base of the management game.

A good deal of the game theory you have applied has been intuitive. You have taken certain facts, and added certain hunches about what the others might do in the process of deciding how you will play. If you had this game stated as a formula and had the necessary computing capacity available, you could actually compute what your best play would be if your opponents took certain action (or actions within certain ranges). If you then also applied your estimate of the probability that your opponents would take certain actions, you could work out what would be the play which would most often be most profitable for you in accordance with your concept of the situation. You could likewise work out the probable consequences (both favorable and unfavorable) of taking another course of action. There would thus be available a valuable device to sharpen management planning and to reduce the impact of uncertainty on business plans.

The theory of games is, as yet, used relatively infrequently—primarily because the mathematics of such complex situations cannot be satisfactorily handled. Undoubtedly, however, this difficulty will be overcome sometime so that we may expect this theory to play an increasingly important role in business life.

The theory of games is only one of a number of theories or models which are being applied to practical business problems. Among the more well-known theories being put to work on practical problems we might mention: (1) mathematical programing (which includes linear programing and transportation type models as special cases); (2) queuing or waiting line analysis; (3) search theory (which is concerned with the development of a pattern of most profitable opportunities); (4) automatic control theory, which includes the formal considerations related to the "feedback" principle; (5) information theory as it pertains to the gathering, processing, and disseminating of data; (6) failure theory as applied to problems involving preventive maintenance policies.

Of course, in addition to the above specific types of models, one utilizes directly some very basic mathematical disciplines, such as: matrices (useful for input-output analyses); probability and statistics (as we have noted earlier); higher algebra (including the theory of equations); differential and integral calculus; concepts taken directly from geometry; and many more, limited only by the nature of the problem and the ingenuity of those responsible for its formulation and solution.

The problems which are now being solved by the mathematical techniques of OR (for this is what we have for the most part been discussing) are certainly not new problems. They have bedeviled the businessman for many years and he has rather successfully coped with them through the application of good judgment. He has produced sound, logical answers to these problems. However, with the assistance of these mathematical techniques, he can normally improve these answers. Generally, if the problem has been carefully studied and the best possible judgment answer supplied, that improvement is not great—often only 5 to 15 per cent, but at times it is less and at times substantially more. This additional improvement, however, can place a company in a far better competitive position and often means the difference between a moderately successful and a highly successful operation, for most of this 5 to 15 per cent is added straight to net profits (or at least to net profits before taxes).

At the present time we must admit frankly that we do not know all of the potential uses for these OR techniques. We do know a good many uses. Let me cite some—stressing once again that we are trying to find the best way to equate a number of interrelated factors.

Inventory control:

1. Variations in lead period
2. Variations in item demand rate
3. Marginal cost of carrying stock
4. Marginal cost of "ordering" or producing lots of various sizes
5. Penalty for being out of stock
6. Exposure to obsolescence

   (Inventories can include such things as repair parts, production materials, salable items, airline hostesses, etc.)

Production scheduling and control:

1. Capacities of machines
2. Length of production cycle
3. Cost, etc., of carrying buffer stocks
4. Influence of lot size on production costs

5. Breakdown probabilities
6. Characteristics of demand for product
7. Cost of emergency production

   (Scheduling and control apply not only to factories but also to such "nonfactory" activities as train movements, etc.)

Facility location—production allocation:

1. Standard of service
2. Production costs
3. Transportation costs
4. Inventory costs
5. Data handling costs

   (The illustration previously discussed at some length is typical of these problems.)

Service facility (men—equipment):

1. Standard of service—cost of delay
2. Cost of facilities

   (Service facilities include the men and equipment provided for such things as toll booths, teller cages, check-out counters, tool cribs, etc.)

Breakdown protection:

1. Probability—frequency of occurrence and duration
2. Standard of excellence
3. Cost of standby facilities
4. Cost of maintenance

   (Applies to such diverse areas as buses broken down, employees absent, machine tools out of service, etc.)

Effort allocation:

1. As—Sales effort
2. As—Product mix
3. As—Quality control

This is obviously not intended to be a catalogue—only an indication of types of areas in which the techniques can be used.

Simulation, the use of models as an aid to more precise decision making, is so obvious an aid to management that its comparatively recent emergence in business would be surprising, except for one factor. Although the mathematics of decision making is relatively simple, the number of computations that must be made in even a fairly uncomplicated business situation is so intolerable that many of the most valuable techniques could never have been used without the development of electronic computers, which can make millions of simple computations in a second.

The second article in this series will outline the relationship between mathematical management—if we can use that phrase—and high-speed data handling.

CLARK SLOAT, CPA AND ARTHUR B. TOAN, JR., CPA

Decision Making—Art or Science?

WHAT IS the relationship between mathematical management—if we can use this term to describe the general process of management assisted by mathematics—and high-speed data handling?

The grand concept of business is that business consists of a large number of complicated interrelationships capable of being expressed in terms of mathematical formulas. Business data processing under this concept consists of two parts: (1) the housekeeping part, i.e., paying employees, paying vendors, billing customers, collecting cash, etc., and (2) the data producing part, i.e., providing the information necessary for the decision-making control cycle. The second part of this job (the production of data for decision making and control) can be thought of as providing the raw material which these formulas need to work. You can, we imagine, easily visualize pouring into a computer a large amount of data about sales, costs, expenses, etc.—factual data taken from the company's records—plus a lot of additional data—about company plans, market conditions, price trends, competitor actions, general economics, and some factors for the probability that certain events will occur and certain actions will take place. Once within the computer, these data would be operated upon in accordance with the rules laid down by the mathematical formulas developed to represent reality. The result would provide a basis for reviewing the past or taking action in the present or planning for the future.

To do this in anything like its complete form would require, even in smaller companies, a fantastic amount of computing capacity. It has not been and, in all probability, never will be done in anything like its ultimate detail.

Neverthless, as a concept, the grand concept is absolutely valid. Express the business relationships as mathematical formulas; feed in data about past or future facts and probabilities; calculate results and choose a course of action; determine actual results and recalculate course of action. So far, this concept has been applied only to a limited area of a business—to inventories, to sales effort allocation, to determining work force needs, etc.

Leaving aside the grand concept, then, how is a high-speed computing system used? It is used in four ways: (1) to solve the formulas when the time required for their solution by other means is excessive; (2) to develop some of the data required to be put into the formulas in the first place; (3) to routinize some lower-level decisions; (4) to facilitate the process of control.

The problem of allocating producing to plants, warehouses, and customers, previously cited, produced a fairly awesome number of complex calculations even with the relatively few facts and relationships being considered. Quite obviously, in a real-life situation, the number of calculations could be extended tremendously by the addition of plants, customers or other factors.

In an oil refinery with which we are familiar, 350 formulas with 500 unknowns are to be used to determine how the refinery should be scheduled to turn what quantity of what crudes into what quantity of what finished products to obtain the maximum dollar profit from the operations. This computation will take, it is estimated, a couple of hours on a very large, very fast computer. This, we hasten to add, is considered to be a relatively simple refinery with many of the more sophisticated time-consuming calculations intentionally omitted. Obviously, then, electronic machines can be useful in solving the formulas.

They can also be useful in producing or processing the data necessary for the formulas—by providing the following opportunities which might otherwise not be available: (1) to break down the data in a more detailed fashion than was previously economical; (2) to produce the data more quickly and/or more frequently; (3) to explore the data to determine the kinds of relationships which actually do exist.

The availability of high-speed electronic equipment can, it can easily be seen, make it possible to analyze data in a more detailed manner. It is obviously more practical to think of manipulating figures into more detailed patterns when the cost of doing so decreases. A more detailed analysis of transportation movements, or of the manner in which materials are used, or of the sources and causes of scrap, for example, can provide valuable data for the mathematical models.

That high-speed equipment can make data available more quickly and/or frequently can also, we believe, be accepted as a general rule even though numerous exceptions can be cited.

About the final use, we should perhaps be more explicit by citing an example falling outside business. A scientist trying to find out how and why something works often conducts a large number of experiments. These experiments produce results to which we shall once again tag the term "data." To find out what these data mean, the scientist will try to arrange them according to all sorts of different patterns to see what kinds and degrees of relationships exist. When the correlation is low or nonexistent, the scientist will probably be unimpressed, unless he is trying to eliminate factors. But when the correlation is high, the scientist will know he has found a significant factor. This process of developing important relationships is partly intuitive and partly mathematical. As the quantity of data increases, the proportion which is mathematical increases tremendously. That is why so much use is made of high-speed computational facilities in our scientific and research world.

Automatic decisions

The same situation exists with business data although, admittedly, we often do not think of it in this manner. It is true that we can seek out relationships and degrees of correlation in much the same manner that the scientist does and that even though the answers may be less exact and as hard or harder to find, what we do find can provide an important competitive edge. In this respect, the high-speed computer holds an important potential. Important work has been and is being done, for example, to determine the value obtained from varying the amounts of sales effort—or from various amounts and types of advertising, just to cite two examples.

Computers can make it eminently practical to routinize a large number of operating decisions.

It can easily be demonstrated that many business actions which we dignify by the use of the term "decisions" amount to very little more than the application of a set of carefully prescribed rules to individual business events. Checking to see: (1) that a credit limit has not been exceeded, (2) that the time has come to follow up a delinquent debtor, (3) that the inventory on hand has fallen below the reorder point are well-known illustrations of this point.

Many of the rules that are applied are capable of expression in mathematical terms—dollars of credit, number of days' supply on hand, number of units, percentage of change from last or normal, etc. A computer, tackling the decision making problem, could compare these mathematically stated rules with the facts of the case. It could, using its skill and facility, accept or reject the customer's order on the basis of its acceptability from a credit standpoint, decide which customers to follow up, decide when and how much to order, etc., or write out for human intervention the relatively small proportion of the situations in which really high-grade human judgment is needed.

A computer could, therefore, apply the rules of mathematical management in a virtually automatic manner to many lower-level operating decisions.

Computers likewise have a contribution to make to the process of control. Perhaps this contribution can be expressed most succinctly by expanding that well-known "catch phrase"—"If you can't measure it, you can't control it"—into—"If you can't measure and compare it, you can't control it."

The essence of control is comparison—comparison with past performance, or with a standard, or with a norm, or with a statistical deviation from a norm—to cite a few examples. Once again, this means that if the events can be stated in numerical terms, and if they can be measured and if the standards of comparison can likewise be stated in numerical terms, a real opportunity exists to use computing equipment to make these comparisons, i.e., to exercise control.

This generally means two things which should be fairly obvious: (1) that the machine can pass over those items falling within acceptable limits, and (2) that the comparisons made can be somewhere between advanced and highly sophisticated in their nature. What may not be quite as obvious is that in the process you can also free a lot of the time of managers which is now spent by them in merely identifying problems and their causes for the more productive work of curing the problems and reducing the chance of their recurrence in the future.

However, to leave the impression that high-speed computing equipment is essential in even a majority of cases would be wrong. Very useful results can be obtained in a large proportion of the cases either without it or with only its occasional use. These results are useful because of the following:

1. Valuable intuitive ideas will result merely from having some smart people look at a situation or a problem area.

2. Often the calculations are not so extensive that they cannot be made by less powerful equipment.

3. It is often practical to omit certain refinements, and thereby to simplify the calculations, without sacrificing too much of the value which could be obtained from the ultimate solution.

4. Many times it is feasible to solve the problem by the occasional use of high-speed equipment and to portray the results in tables, charts, or graphs which can be used in day-to-day operations.

Thus, to use some terms we used before, the correlation between mathematical management and high-speed electronic equipment varies all the way from unnecessary to nice to essential.

All of this is not, of course, quite as simple as it may possibly have been made to sound. Limitations on the usefulness of these methods do exist; we merely made the deliberate choice not to clutter up the consideration of the basic ideas with a lot of qualifications, but instead to treat these limitations en masse.

Some of the limitations represent just as severe limitations on the application of intuitive judgment. We should, however, think about them briefly because of the apparently unavoidable human characteristic of imputing a high degree of precision to almost everything which is expressed in mathematical terms—whether this is deserved or not.

The limitations are these:

1. The inability of people and machines to ferret out of the mass of business data which is available a precise statement of the relationships and interrelationships which exist. This problem, it might be added, is in no way helped by the fact that many of these relationships conflict in such a way as to obscure rather than to clarify real causes and effects.

2. The great difficulty of predicting with a high degree of accuracy the impact of some new event—military, economic or technological, or even a hit TV show—on your or your competitor's position.

3. The absence of a great deal of important information about past actions and events—information which was not kept because it was considered of only transient significance. We can often tell, for example, what happened but not the conditions which existed nor the reason for the action and not the consequences of taking the action or of not taking it. To choose a very simple, yet key bit of information which is rarely available—how often were we out of stock and what were the consequences of this?

4. The basic absence of information about the past, present and future acts of our competitors and of the business world in general.

5. The fact that in many instances we are concerned with marginal or incremental values and costs—with the net marginal gain from stocking more or less inventory, with the net marginal gain from changing the staffing of a toolroom, with the net marginal gain from changing the

maintenance policy, etc. This information is not normally available at present—or at least, not without many approximations and/or a great deal of digging. As a matter of fact, many thoughtful accountants believe that a new or at least drastically modified concept of accounting and record-keeping may be necessary before this information does become readily available on a reliable and routine basis.

6. The difficulty in placing a concrete value on some of the intangibles—customer goodwill, good employee morale, community reputation, etc.—which form an important consideration in many business decisions.

7. The need to develop additional mathematical techniques which are capable of coping with some of the problems and relationships of business. A number of mathematical methods now in use, strange as it may seem, did not exist ten to twenty years ago but were created to fill the need. Still more are waiting to be developed.

8. The fact that computers themselves with all their power and abilities can be and often are physically and economically outstripped by the size and complexity of business problems and relationships.

This sounds like a fairly imposing set of limitations and it is. But imposing as they are, they do not offset the present and potential power of OR as a valuable aid to management.

One question which is often asked by business executives is "How do we organize to use these methods?" From the previously cited list of problems you can undoubtedly recognize many problems which would be susceptible of solution by OR techniques. The question, therefore, of what to undertake seems to be the simple one. The problem of how to undertake it is not quite so easy.

First, you must have available a competent technician. These people are not easy to find. Your degree of success in OR technique will, however, depend upon the quality of the personnel employed in the effort. The operations researcher to be effective requires a rather broad knowledge of many different scientific techniques. He must know probability statistics, differential equations, calculus, etc., as well as many of the concepts which have been developed in the physical sciences. He must know when he cannot use a mathematical expression for a normal distribution or a Poisson distribution, when to use certain mathematical theorems, when to use linear programing, when to use game theory, as well as all of the other various tools which have become available.

After you have a technician, it is necessary to supplement his efforts with those of people who know and understand business operations. This may be contradictory to the statement of many of the well-known operations researchers, but it has been our experience that solutions to problems are obtained far more quickly and in a far more practical manner if the team studying the problem includes someone who is thoroughly acquainted with the operation under study. No benefit can be obtained from any technique unless a practical, usable solution is derived. Therefore, it is necessary to avoid a completely ivory tower approach, and put emphasis upon the practicability of results. On the other hand, you should not completely discourage a certain amount of research beyond the requirements of the immediate problem, for in the longer view one can expect a payoff for such freedom as a result of the basic stimulation which your OR man receives under such conditions.

No one can provide a nonmathematician with sufficient knowledge of the techniques in a short time to enable him to carry out the technical parts of the studies. The important thing for the nontechnician is to know that mathematical techniques are available for stating some of the complex relationships which exist in business today. It is important for the nontechnician also to know that with some study and effort he can generally check the logic expressed in these mathematical relationships, so that he is able to provide the technician with the benefit of his knowledge of the intricacies of business relationships and to apply common sense checks to the results.

We are just on the threshold in the development and use of these techniques. We have, however, learned enough even at this point to know that despite their limitations, they can be highly beneficial and often lead into relatively new concepts in the solutions to problems. We do not know enough about applications at the present time to fully define all types of problems which may be susceptible of solution through use of these methods. We do know that the area of applicability is very broad.

We do know that the methods and techniques of science can contribute to the art of business management.

CHAPTER

8

Some Tools of the Scientific Manager

Operations Research

The Challenge of PERT/Cost

Statistical Analysis

E. LEONARD ARNOFF AND M. J. NETZORG

Operations Research

IT IS a cliché that the problems confronting business decision makers today are more complex in nature and more far-reaching in scope than ever before. Fortunately, new methods, techniques, and tools are also making decision making easier—for the executive who is able and willing to use them.

One of the most important of these new techniques is operations research. For orientation of businessmen and consultants who have not yet had personal experience with its use, this article describes operations research—what it is, where it originated, how it is used in problem solving, and where it has been applied in industry.

Operations research (commonly referred to as OR) is the systematic, method-oriented study of the basic structure, characteristics, functions, and relationships of an organization. Such study is intended to provide the executive with a sound, scientific, and quantitative basis for decision making.

Operations research is based on the fact that in economic systems, just as in the physical world, there is a great deal of orderliness, even where this is not readily apparent. Thus, OR is concerned with determining (1) how a system behaves under a wide range of conditions, (2) the relationships which explain why the system behaves in this manner and, finally, (3) the manner and timing through which this behavior should be changed so as to best achieve the organization's goals.

Operations research is concerned with the relationships of the activity under study to all other *pertinent* elements of the system. It is also concerned with evaluation of the host of possible alternative courses of action open to the decision maker.

The roots of operations research are as old as science and the management function. OR uses techniques adapted from many fields, such as physics, psychology, industrial engineering, and—most particularly—symbolic logic, mathematics, probability, and statistics. In addition, new methods, techniques, and tools have been developed or adapted specifically for OR-type problems. Many of these developments are of recent origin—within the past five to ten years—so that one can now solve scientifically a host of important problems that were heretofore handled on a judgmental basis.

The capabilities, flexibility, speed, and scope of usefulness of electronic computers have aided in the growth of operations research. They have made possible the study and solution of problems of a complexity that was previously beyond the time limits that confront any feasible number of individuals, no matter how competent. Some operations research techniques require the use of computers, but in a number of areas highly effective work can be accomplished with little or no use of computer time. Under no circumstances is the computer a substitute for intelligence, thought, business imagination, and acumen.

The results of successful operations research, for the decision maker, are these: (1) assistance in substantially improving the operations under his control and better achieving the goals of the organization; (2) increased knowledge and insight into the basic facts, characteristics, and relationships of the business; (3) more effective, more responsive, and broader control; (4) better, more timely, and more quantitative information; (5) a reduction of the time and effort required for routine decisions ("management by exception"); (6) more time for planning and managing.

Operations research has become increasingly useful to management, especially for solving those problems which affect more than one functional unit (division, department, section, etc.) within a firm. Such problems involve conflicts of interests, where a policy most favorable to one unit is rarely most favorable to the others. These conflicts of interest must be resolved to determine those policies and decisions that will maximize the effectiveness of the organization as a whole.

These problems have been called "executive-type" problems. They have arisen as a direct consequence of the functional division of labor in business enterprises—brought about by the rapid growth, diversification, and decentralization of industry. With the increased segmentation of the management function came increased attention of applied scientists to problems generated in the various functional units. From their efforts emerged a number of branches of applied science—including chemical, industrial, and mechanical engineering; industrial psychology; statistical quality control; industrial economics; and others. As each functional unit developed and better achieved its own objectives, executive-type problems increased in frequency and importance.

The solution of executive-type problems demands a highly refined balance of departmental objectives and overall corporate objectives. *Operations research is devoted to the solution of executive-type problems—to provide management with a scientific basis for solving problems involving the interaction of functional units of the organization in terms of the best interest of the total organization.*

To illustrate an executive-type problem, consider briefly some of the objectives and conflicts involved in the inventory decisions of a firm:

Manufacturing seeks to minimize the unit cost of production (including set-up costs); hence, it favors long, uninterrupted production runs. This would result in large inventories composed of relatively few products.

Personnel is also interested in inventories. It wishes to stabilize labor and minimize the costs of hiring and layoff as well as employee discontent. This can be achieved by producing to finished inventory during times of slack customer demand.

Sales seeks to give outstanding service to customers and, hence, wishes to maintain a large inventory of a wide variety of products readily accessible in many locations. Further, it wishes manufacturing to be flexible and able to fill special orders on short notice.

Finance generally seeks to minimize the capital tied up in inventory and, hence, wishes a high rate of inventory turnover, that is, low inventory levels.

Other departments are also seriously affected by the production and inventory plan that is selected.

These objectives are, of course, in conflict with each other. The problem here is to determine the inventory policy which is best for the organization as a whole. Almost every managerial position is affected by the operating plan that is chosen and how well it is executed. However, because of the diverse objectives, and especially because of the conflicts among the objectives, choosing a plan is a controversial executive problem. Where the decision is made through negotiation and depends on the relative powers of persuasiveness of the individual departmental or divisional executives concerned, the outcome can easily be a plan of action that is far afield from what would best serve the company's overall interest.

It is under such circumstances that operations research is of highest value. It is a highly useful means by which to clarify and simplify decision making in the face of business uncertainties and risks, such as incomplete knowledge of future sales volumes and of the plans of competitors; in the face of a multiplicity of alternative courses of action; and in the face of conflicts of interest within the company.

Another type of situation where operations research is highly useful is under conditions where conflict of interest may be secondary in importance but where there are a great number of factors to be considered, highly complex interactions, and a sheer bulk of data.

Since operations research is a relatively new discipline, let us discuss its origin and development and how it works—and give a brief description of a few of the hundreds of decision areas in which it has been successfully applied.

Origin of operations research

Operations research's development began in the United Kingdom in 1939 when a group of scientists was assigned to the Operational Staff in Britain's military organization. This group of scientists included physicists, psychologists, engineers, mathematicians, and others. The group was divided into teams to study large-scale military problems. The inclusion of several disciplines on a team was found to lead to gratifying results in that the interplay among the scientists often yielded new and successful approaches to complicated problems. Outstanding contributions to the war effort included the effective use of radar, the allocation of British Air Force planes to missions, and the determination of the best patterns to be used in searching for submarines.

The dramatic success of these first efforts led to the formation of more such groups in the British armed services and in all branches of the United States military organization. Today, a substantial number of operations researchers are engaged in military operations research.

Immediately after World War II the methods and techniques so successfully applied by the military were adapted to business and industry. Further developments, many of them along new lines, have also been successful. It is this rapidly increasing body of knowledge—methodology, techniques, and special analytic approaches—that gives strength to operations research as it exists today.

Operations research, like all scientific research, is based on scientific methodology, which may proceed along the following lines:

1. *Analysis of the system*—to determine the objectives of the study and the specifications, form, and characteristics of the solution to the problem. Before this can be done, there must be a good, unbiased work-

ing knowledge of the existing system. (This is materially assisted through flow charting the relevant parts of the business under study). Basic to this stage is identification of decision points, plus determination of relevant factors and the extent to which they are subject to control. The eventual solution, accordingly, is conditioned by restrictions as to what must be done and what must not be done, as well as by consideration of limiting values and expressions of management policies.

It is at this stage that the general approach is established and the problem is formulated and often partitioned into interconnected subproblems. It is at this stage that broad appraisal is made as to both the cost and the pay-off value of a successful study and estimates are made of the required time and effort. This, combined with an appraisal of the difficulty of the study and the probability of its success, determines whether it is worthwhile (feasible) to undertake an operations research study—and, if so, in what scope and depth.

This first stage, as described above, is commonly referred to as an *orientation-feasibility study*. An important product of the orientation-feasibility study is a detailed research plan which sets forth the one or more phases of the study in such a manner that, phase by phase, results can be implemented and benefits achieved without awaiting the completion of the full study.

2. *Construction of a representation of the system*—a "model"—that has sufficient likeness to the real situation so that the model, rather than the system, can be manipulated meaningfully. The formal model is usually a mathematical representation of the system under study, designed in such a way as to facilitate the most effective evaluation of the influence of the various factors that affect the decisions.

3. *Testing the model.* The model must reflect those (and only those) real-world conditions that are pertinent to problem solution. Collection and analysis of pertinent data then lead to appropriate modification and refinement of the model.

4. *Solving the model.* The model is then solved; that is, for any given set of conditions within stated policies and restrictions, the model is used to establish recommended courses of action. The analyst also calculates the effect of relaxing or tightening restrictions or of changing one or more policies.

5. *Controlling the model and solution.* At this point, controls must be established to indicate the limits within which the model and its solution can be considered as sufficiently reliable and to indicate under what future conditions and in what manner either the model or solution will have to be modified.

6. *Implementing results.* Finally, when the research is at an appropri-

ate stage of progress, steps must be taken to put its findings to work.

The use of a model is commonplace; for instance, every factory schedule is a model. The accounting system of a firm is also a model, and often a very complex one. The power of operations research model building is that it is able to encompass a multitude of factors and a multitude of yardsticks and, hence, to resolve highly complex problems. A schedule is a model whose primary yardstick is time, with money important but secondary. An accounting system turns all the variables to money values, so that all other variables play a secondary role. The operations research approach typically involves a delicate weighting and balancing along interlocking measurement scales.

The use of an operations research model is especially important and advantageous in that it permits experimentation "on paper," without manipulation of the actual system. In using the model, one can assess the *sensitivity* (response) of the system to a wide variety of conditions—without requiring either the time, expense, or risks associated with experimenting with the system itself (if such experimentation would, in fact, be possible and meaningful). The appropriate transition from one set of conditions to another set of conditions can also be determined. Hidden relationships can be brought to light and brought to bear upon decisions and control of activity. Accordingly, operations research is particularly advantageous in dynamic (changing) situations.

The operations research approach to a problem gives consideration to the practical solution, as contrasted to the purely mathematical, or theoretical, solution. Analyses are performed to determine when further research or refinement will be more costly than the potential savings. Alternative solutions, indicating the cost of deviations from the computed optimal solution, are also derived and presented to management, thus giving management a better basis for selecting from among a group of alternative courses of action.

The use of operations research assures a sufficiently complete solution to a problem rather than a "patchwork" solution. The tendency in industry and business today is to be in a continual state of fire-fighting, treating the *symptoms* of problems rather than the true *causes*. Furthermore, the best solution for a particular component of a system when studied in isolation may be quite different from the solution when the overall system is studied. For example, the stockage policies at a group of warehouses will generally be different when each warehouse is considered individually than when the total warehousing system is considered.

Since operations research is frequently involved in research, as contrasted to the application of previously developed techniques, there always exists the possibility of not being able to arrive at a full solution.

However, the methodology of operations research provides an approach to problem solution that maximizes the probability of success in accomplishing the research objectives.

In summary, operations research, when applied to suitable problems by competent practitioners, leads to proper solution of problems—problems that could not be so clearly and decisively understood, stated, or handled by any other means.

Operations research has been applied in virtually every kind of business and industry. Among others, it has been used extensively in the petroleum, paper, chemical, metal processing, aircraft, rubber, transport and distribution, mining, and textile industries. Operations research has been very successful in aiding executives in solving problems in such areas as these:

Production

- Planning and scheduling
- Purchasing—materials and supplies
- Raw material and in-process inventory management
- Make or buy decisions
- Allocation of fixed facilities and manpower
- Equipment and materials utilization
- Maintenance and replacement of equipment and facilities
- Waiting lines (bottlenecks)
- Plant location

Marketing and distribution

- Allocation of sales effort
- Salesmen's compensation plans
- Allocation of advertising dollars
- Evaluation of advertising effectiveness
- Product mix
- Finished goods inventory management
- Pricing and bidding strategy
- Forecasting (demand, supply, price)
- Warehouse location
- Centralization vs. decentralization
- Transportation
- Warranty
- Customer service

Investment and finance

- Facilities planning
- Selection of process and equipment
- Replacement policy

Diversification and acquisition
Budgeting
Portfolio selection
Sampling and accounting
Financial planning and control
Financial forecasting

Organization
Organization structure
Centralization vs. decentralization
Communication
Long-range planning
Organization of problem solving groups
Stockholder control

Others
Evaluation of problem solving groups
Research and development expenditure
Design of experiments
Urban planning and area redevelopment
Various uses of sampling
Credit analysis (e.g., credit card accounts)
Benefit plans—executives and employees
Decision-oriented management information systems

The following brief descriptions give further indication of the immense range of problems and situations where operations research has been successfully applied. While reference is made to studies in specific industries, the problems involved often have basic underlying structures that conform to general types. So the solutions that were obtained could be paralleled in many industries, with those modifications required to take full account of the individuality that gives truth to the saying . . . "but my business is different."

The design, development, and implementation of an optimal production and inventory management system—in a machine-tool company. This application covered the planning and control of the ordering; scheduling; sequencing; dispatching; machine loading; warehousing; assembly; and raw, in-process, and finished goods inventory functions. Included also were analyses and appropriate changes in data collection, generation, and processing (computers and *decision-oriented* management information systems) and in forecasting decision rules and procedures were developed for both day-to-day operation and long-range planning.

Production planning and labor stabilization—in the rubber industry.

In an industry where demand is highly seasonal, factory production rates and manpower levels were determined so as to minimize the sum of the costs of (1) hiring and layoff of personnel, (2) carrying inventory, and (3) overtime.

Planning and scheduling of materials, processes, manpower, and facilities—in a refinery complex. A method was developed for determining the selection and use of resources so as to maximize profit. Price-volume relationships were analyzed, and optimum product mixes were established for market planning. (This is an extension of optimum blending procedures for gasolines, middle distillates, and heavy fuel oils.)

The selection and scheduling of research and development projects—in the pharmaceutical industry. The estimated pay-off, cost, effort, and likelihood of success were determined for each potential research project. Available funds, manpower, and skills were then allocated so as to determine an overall research program with greatest profit potential.

Maintenance and replacement program—in a trucking company. The study determined the optimum preventive maintenance and replacement program. The structure of the system was analyzed for a variety of basic alternative policies. Included in the analyses were the costs of maintenance and road failures.

Group replacement vs. individual replacement—of light bulbs in manufacturing companies and municipalities. For items that do not deteriorate with age or with use but which ultimately fail, the determination is made whether or not to replace in a group and, if so, when to do so. This problem arises since the cost per unit for group replacement (before failure) is less than the cost per unit for individual replacement (after failure).

The maintenance of mechanical equipment—for large, worldwide governmental agencies. These studies were concerned with the optimum number and location of maintenance shops, personnel requirements, stockage policies at depots and in the field, and the question of assembly vs. component part replacement.

The determination of optimum reserve generating capacity—in the electric utility industry. An analysis was made of shortage policies, maintenance programs, customer demand, and interconnections—to determine when to add generatorss and of what size. A major task here was the determination of the probabilities of equipment breakdown (forced outages) for the total system.

The determination of warehouse dock facilities—for a department store. Variations in the number and time of daily truck arrivals, the servicing times (loading and/or unloading), restrictions on the parking facilities, and customer and company truck waiting times were taken into account in determining the dock requirements for a warehouse which was to replace three existing warehouses.

The determination of facility requirements (cranes, docks, etc.) to accommodate the expected volumes and mixes of ores and coal received at a port. Factors considered included (1) the characteristics of ships arriving at the docks, (2) the effects of these characteristics on unloading rates and dock space, (3) limitations on the number of ships that can wait in the harbor, and (4) the cost associated with ships delayed in unloading due to insufficient facilities versus (5) the cost of idle unloading facilities.

Establishing, monitoring, and updating master plans for urban renewal and city planning. This requires integrated analyses of growth patterns (population and industry); the resulting effects on city income; and the sociological implications of various housing, recreational, office, and transportation systems.

The allocation of salesman effort—for a light-bulb manufacturer. This study involved determining the number of salesmen needed, sales territory boundaries, and the number of sales calls to make on each type of dealer so as to maximize the total profitability of the sales effort.

The establishment of an optimal distribution system—for a bulk-chemical producer. Optimum product mix, product reorder levels and order quantities, number and location of warehouses, the assignment of customers to warehouses, and the assignment of warehouse facilities to production plants were determined. Storage, transportation, and production costs, as well as customer service levels, were considered.

The selection of coal for coke plants. The objective of this study was to minimize the total cost of a given amount of coke. The costs of transportation, mining, and conversion (coal to coke) were included, along with consideration of the availability of coal at each mine and the capacity at each coke plant.

Planning for seasonal retail sales. Sales patterns for numerous products—sold by approximately 10,000 dealers with different geographical locations, types of stores, and sales volumes—had to be considered in developing a sampling plan for estimating end-user purchases. The results were then used to develop production, distribution, and marketing programs in a highly seasonal business.

The determination of an optimal warranty system—for a durable goods manufacturer. This study included the evaluation and change of settlement policies; where and by whom the claims should be settled; optimum product quality level; and how product problems can be quickly detected, evaluated, and corrected.

The development of bidding strategies for obtaining leases for oil exploration. Included in this study were the development of a predictor of future production for a given lease and an analysis of the relationship between the amount bid and the likelihood of obtaining the lease for that bid.

Great care must be taken to assure that the right problem is being formulated and then solved—in its proper scope. As noted earlier, the use of an operations research model is especially advantageous here, inasmuch as it permits assessing the response, or sensitivity, of the system to a wide variety of conditions. In particular, it enables the analyst to determine the sensitivity of the solution to individual factors and, in turn, to determine the importance of such factors in obtaining still further improvements in the system.

A study conducted for an airline illustrates the operations research approach in assuring a complete, yet practical, solution:

A commercial airline sought to determine (1) how frequently it should conduct classes for the training of stewardesses, and (2) the size that these classes should be. This rather limited problem was formulated precisely, and a decision rule was obtained for administering the school so as to minimize the sum of the costs involved.

In the course of solving the problem, the operations research team discovered that the effectiveness with which the school was operated was very sensitive to the number of stewardesses required by the airline. Consequently, an investigation was undertaken as to how these requirements were determined at each base and, hence, for the total system.

This led, in turn, to the development of a procedure for minimizing the number of stewardesses (including reserve stewardesses) required at each base. This step required developing (1) new procedures for the preparation of individual flying assignments ("bids," prepared monthly) and (2) new provisions for "makeup" flying whenever flying assignments were missed (due to cancelled flights, etc.).

However, this investigation revealed that a base's requirements for staffing were sensitive to the assignment of flights to that base and that the total system's staffing requirements were sensitive to the number and location of bases and the assignment of flights to each of them.

A study was therefore undertaken to determine: (1) how many bases there should be, (2) where the base should be located, and (3) how the flights should be assigned to each base in order to yield the best possible performance of the total system.

However, since flights could not be assigned to bases without considering the male crews (the male crews and stewardesses flew the same monthly "bids"), the study was finally generalized to consider the total crew.

Once each of these aspects of the system's operations had been analyzed, the results of the several phases were synthesized and overall planning procedures for training and utilization of personnel were developed.

Further studies of utilization of aircraft, maintenance policies, etc., were also suggested by the study, because of relationships which were revealed. These studies were subsequently undertaken. In addition, the study and its corresponding model put the company on a better basis for conducting its negotiations with the flight personnel unions, inasmuch as the implications of new contract terms could be determined in advance.

In this example, the "symptoms" were not indicative of the true problem; it was the overall approach that eventually indicated the total problem that had to be solved. However, the intermediate steps were so conducted that the solution was optimized each time, subject to the constraints imposed by the rest of the system.

It is important to note that the benefits obtained from solving the overall problem were substantially greater than those that would have been obtained by solving the limited problem originally stated.

For each specific project, an OR task force should be formed consisting of qualified operations researchers as well as personnel directly involved with the subject area under study. These latter personnel will supply necessary technical knowhow and experience, will assist in collecting and generating data, and will also assist in working out the details of implementation.

The joint task force should, in turn, report to a steering committee consisting of the managers (or representatives) of those functions of the company most vitally connected with, and affected by, the study. The steering committee should usually consist of three to five members, although at times it is desirable to have additional representation. The task force should meet regularly with the steering committee, approximately two to four times per month, and with individual members of the committee even more frequently.

In turn, the task force and the steering committee should meet with a top management committee—typically every six to ten weeks. Ordinarily, the top management committee for the OR study is a regularly functioning committee already in existence. This committee is usually a fairly large one including representation from each and every major function of the company. In many instances, members of the steering committee are also regular members of the top management committee.

In some instances the nature and scope of the problem, as related to the company structure, are such that only a single management committee is needed, usually consisting of three to ten members.

The use of the operations research task force, a steering committee, and a top management committee yields many important benefits—so important, in fact, that it is safe to assert that *an operations research study will seldom be effective unless such committees are used.* With proper use of the committees, the benefits include the following:

1. These committees serve as filters for the research, help prevent errors of both commission and omission, provide additional know-how, and generally guide the team *during* the study, thereby increasing the chances of success. (In particular, interactions among functions are uncovered where they might otherwise be missed.)

2. Since the committees represent the areas affected by and involved in the study, the OR team is not put in the position of an outsider (e.g., staff) trying to tell others (e.g., operating personnel) what to do. Everyone has a sense of participation and contribution and also a much better opportunity for discussion and, hence, understanding, thereby increasing chances for acceptance and successful implementation. Furthermore, implementation can then be carried out more readily and quickly.

3. Several levels of management and operating personnel are thereby educated in the nature of operations research, making them more aware of its potentialities and its limitations.

The success of operations research in any company often depends as much on management as it does on the operations research staff. Hence, wherever possible, the informal discussions on operations research at the committee meetings should be supplemented by a series of formal sessions on OR—designed to develop a better understanding by management. Such sessions have been conducted—with great success—in a large number of companies.

4. Further OR projects will usually be suggested by these committees, thereby inducing a better acceptance of and environment for operations research at all levels of the company.

Pitfalls in OR

Whenever operations research is mentioned, executives are likely to express some bewilderment over the fact that results have ranged all the way from limited success to the highest usefulness and profitability.

So far, this article has discussed the steps, the procedures, the attitudes, the probings, and the methodology—which are a minimal basis upon which to build toward success. In so doing, the positive side has been accentuated. However, there is also a need to point out the negative side. Certain common traps and pitfalls can easily be, and have been, the ruination of otherwise good work. Some of these pitfalls are fairly obvious, while others are so subtle and deeply hidden that unless careful heed is taken their presence is not even suspected.

At the very outset of problem solving—the problem selection and formulation phase—a number of pitfalls can and do arise. Here, the executive and the operations researcher have the joint task of selecting the right problem and of defining it completely and accurately. Is the right problem being solved? Is the problem being considered in its proper scope, or will the gains be localized and at the expense of other parts of the organization ("sub-optimization")? Will the solution pertain to the actual system under study and properly reflect the goals of the organization as well as the imposed restrictions? Are appropriate measures of performance being used? The problem formulation phase is probably the most important and most difficult part of the entire study. Deliberate and skillful planning is especially required here.

Data gathering can represent a very large part of the time and cost of an operations research study. Hence, an early analysis of the sensitivity of the solution to the input data should always be made, since it will save gathering unneeded data and will often indicate the areas in which measurement and control (and, hence, better data) are most important. Fortunately, a system reasonably close to optimum usually gives excellent results. Hence, rough, order-of-magnitude estimates will often give considerable insight into system behavior and results.

Solving the problem also contains some potential dangers. Not the least of these is over-concern with the elegance of the solution, which can lead to an elaborate and correct answer that may be too late or too complex to be used. It also can lead to "over-optimization," that is, attempting to obtain the last few percentage points of improvement by a detailed and expensive analysis. A less complicated model will often yield most of the potential gain, at considerably less cost and with much greater likelihood of success; in fact, the cost of any further gain may well exceed the gain itself.

Other pitfalls in problem solving include: (1) taking a "cookbook" approach when a custom design is needed (as, for example, precipitous use of standard lot-size formulas); (2) warping the problem to fit an available model, technique, or tool; (3) substituting high-speed, brute force computer groping for sound analysis; (4) failing to test the model and the solution adequately prior to implementation; and (5) failing to establish proper controls on the results.

Estimating benefits from system improvements requires a word of caution, in that theoretical benefits are usually not completely achieved and potentials must be discounted in order to give realistic, practical expectations of accomplishments. The disappointment of not fully achieving a potential gain can overshadow the benefits that are actually attained, even when such benefits are sizable.

A number of operations research studies have not realized great potential because the results were not fully accepted. Many of these studies were technically sound, but the operations researcher failed to communicate properly with management. It is the operations researcher's responsibility to translate his highly specialized and technical thoughts, concepts, and ideas into the realm of experience of the executive and into the language of the business and to translate complex solutions and formulas into tools and procedures that can be readily used. Further, it is essential that the operations resesarcher determine and develop the procedures necessary for smooth transition from the original system to the new system.

One further word of clarification is that, in fact, a truly optimum

DO'S AND DON'TS OF OPERATIONS RESEARCH

In problem selection and formulation:

- Do solve the right problem.
- Do consider the problem in its proper scope.
- Do use appropriate measures of performance.
- Do develop a solution pertaining to the actual system under study.
- Do develop a solution properly reflecting the goals of the organization.

In solving the problem:

- Don't be over-concerned with the elegance of the solution.
- Don't over-optimize.
- Don't settle for a standard approach if a custom design is needed.
- Don't warp the problem to fit an available model, technique, or tool.
- Don't substitute high-speed computer groping for sound analysis.
- Don't fail to test the model and solution adequately before implementation.
- Don't fail to establish proper controls.

solution is never achieved. Rather, what is called an optimum solution is such only for the problem as specifically stated, the area covered, and the conditions that existed at that point in time. However, the fact that a solution may not be truly optimum does not mean that substantial gains cannot be achieved.

Finally, what may appear to be a pitfall is the fact that a good operations research study may raise more questions than it answers. However, this can lead to a more penetrating inquiry into the operation of the system and what it is intended to do—with the ultimate result of greater insight into the system and even more far-reaching benefits and improvements. This inquiring aspect of operations research is one of its strongest attributes.

DON T. DECOSTER, CPA

The Challenge of PERT/Cost

EACH DAY that passes sees the growth of new management planning and control tools. Many of these new tools leave the accountant with the unhappy feeling that he should be participating in their use but that he lacks the orientation for active involvement. The desire of the accountant to become involved with these tools is evident from the growth of "management planning and control" chapters in textbooks and the numerous articles dealing with the managerial aspects of accounting output.

One of the newest tools, if evidenced by current publications, is Program Evaluation and Review Technique (PERT). Recently, there have been many discussions, publications, and applications of this technique. PERT's acceptance has been widespread. The accountant must become involved with PERT if he accepts the challenge of Norton Bedford that "the accounting profession has the potential to become one of the great professions if it will accept all phases of measurement and communication of economic data as within its province."[1]

The principal motivating factor in PERT development has been the growth of the concept of systems management within the military services. With programs of unprecedented size, complexity, and breadth, an integrating device has become mandatory. In addition, time is of the essence in weapons system design and development. PERT/Time has

[1] *John L. Carey, The Accounting Profession: Where Is It Headed? American Institute of CPAs, New York, 1962, p. 94.*

been a powerful tool in the kit of managers for planning, co-ordinating, and integrating these weapon systems.

The culmination of PERT/Time is the network. This network is a pictorial representation of the events and activities that lead to completion of the end objectives. The events represent the beginning and/or ending of activities. An *event* is a specific accomplishment, or milestone. The *activities* represent things that must be done in going from one event to another. The activity is the time-consuming task. The activities are related to their order of precedence in accomplishing the events. The end result is a network depicting a well-thought-out plan. After the flow of activities and events is mapped, schedule timing can be superimposed. When completion times are included on the activities, the critical path (longest time path) can be determined.

At this point the manager has a tool which needs no further justification. The network presents a clear picture of all the activities and events that must be accomplished before the end objective can be attained. The individuals with responsibility for accomplishment will have discussed all of the relationships, potential drawbacks, and completeness of the plan. When times are imposed upon the plan, the problems of a timely completion are apparent. The activities affecting timely completion and the schedule's effect on workloads are laid bare for scrutiny. When actual times become available, the updated estimates provide a dynamic control tool to anticipate adverse results. There can be little question that PERT/Time is a tool which, when applied with common sense and vigor, represents a "breakthrough" in management planning and control of the valuable resource of time.

PERT/Cost is, in reality, an expansion of PERT/Time. With times indicated on the network, it becomes possible to consider alternative plans of action. As the network is being developed, time options are presented which can be considered. Techniques of system stimulation can be employed to ensure that the activities and events will lead to the best climax. The next logical step, with time options available, is to obtain the optimum mix of time and cost. This has led to the attempt to assign costs to the activities on the network. An additional advantage when costs have been assigned to the network for time-cost options is that they can be summed for total cost planning and control.

The development of a system for cost accumulation synchronized with PERT/Time network must be founded upon objectives consistent with the responsibility of management. In program management, the manager is faced with a twofold job. He is charged with the financial planning and control of his firm's resources, while at the same time he is committed to delivery of the end items with a minimum of cost incurrence to the customer.

This was recognized by the developers of PERT/Cost, NASA and the Department of Defense, when they visualized it as a three-part system.[2] Basic PERT/Cost is intended to assist the project managers by assigning costs to the working levels in the detail needed for planning schedules and costs, evaluating schedule and cost performance, and predicting and controlling costs during the operating phase of the program. In addition, there are two supplemental procedures. The Time-Cost Option Procedure displays alternative Time-Cost plans for accomplishing project objectives. The Resource Allocation Procedure determines the lowest cost allocation of resources among individual project tasks to meet the specified project duration. The basic system is to provide total financial planning and control by functional responsibility, while the two supplements are to achieve minimum cost incurrence.

The concept of cost predetermination for planning and control is not new to the accountant. The entire function of budgeting is predicated upon predetermination. Comprehensive budgeting relates income budgets, covering revenues and expenses, to the financial goals of the firm. The expense budgets lead to financial planning and control via projected income, while at the same time the flexible budget and the expense forecasts serve as tools for decision making by relating costs to volume.

PERT/Cost estimates are a new way of looking at the expense budgets. If properly conceived, they can become an integral part of the comprehensive budget program. Yet they differ from conventional expense budgeting in certain respects. From the financial planning and control viewpoint, the PERT/Cost estimates are not concerned with accounting periods. PERT/Cost is activity oriented. There is a cutting across of organizational structures and time periods to define "things to be accomplished." The focal point of cost accumulation shifts from the department to the project work package. The annual budget is bypassed to encompass an end item accomplishment. From the detailed decision making viewpoint, where the flexible budget normally uses volume as the factor of variability, PERT/Cost attempts to use activity time. These two differences will now be examined in more detail.

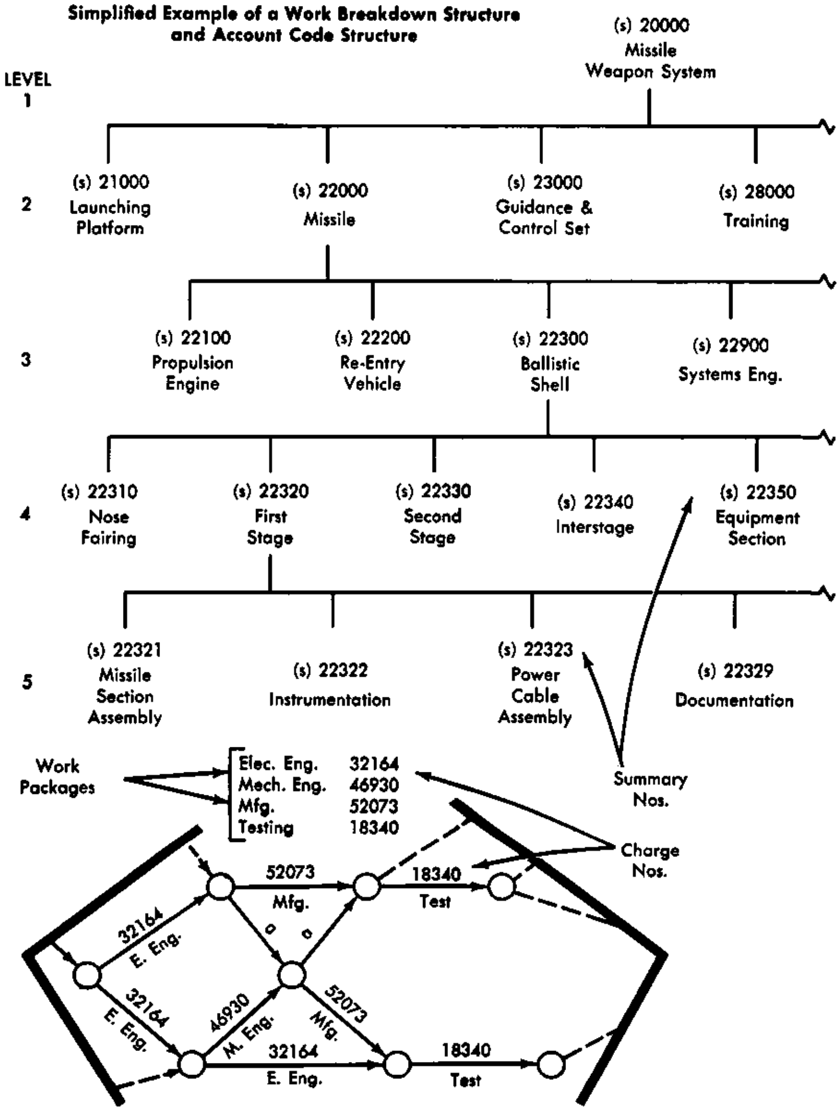
Cost framework

The establishment of a PERT/Cost system begins by developing a framework for gathering cost data and preparing the schedule for all activity levels. The project is defined, then broken down into end item subdivisions, and then into work packages which are assignable to front-

[2] *DOD and NASA Guide: PERT/Cost. Published by the Office of the Secretary of Defense and the National Aeronautics and Space Administration, June, 1962.*

line supervision. The integration of the work packages is accomplished through the conventional PERT/Time network. When the interrelationships and time paths have been plotted, the responsible operating and managerial personnel develop cost estimates for each work package.

It is important that both cost and time be planned and controlled from



a common framework. From such a framework, the managers can obtain an accurate picture of progress and at the same time appraise realistically the consequences of alternative courses of action. The PERT/Time network is this common framework. This imposes upon the network developers the responsibility of carefully defining the activities so that they can represent cost centers as well as the areas of work effort.

The identification of the project objectives in terms of end items is the starting point for network design to be used with PERT/Cost. By using a top-down approach in the development of the network, the total project is fully planned and all components of the plan are included. Standard units for the breakdown of work below the project level are system, subsystem, task, and subtasks. The work breakdown continues to successively lower levels until the size, complexity, and dollar value of each level is a workable planning and control unit. These subdivisions are end item subdivisions representing horizontal segments of the total project. The final step would be to divide each of these end item subdivisions into the tasks that must be done to complete them; i.e., design, manufacturing, testing, and so forth. This concept is demonstrated in the illustration[3] on page 252. It is this project work breakdown that serves as the input data to the network.

The theoretical optimum level of cost accumulation would be the functional level of each of the end item subdivisions. For example, a cost account would be established for mechanical engineering of the instrumentation, one for manufacturing, and one for testing. The PERT/Cost estimates would then be made for manpower, material, and overhead charges for each of these work packages. It is obvious that a cost accounting system broken down into such intricate detail would comprise numerous accounts. The pragmatic number of account subdivisions will naturally depend upon the detail needed for planning and control, the dollar value of the subdivisions, the activity time on the network, and the machine and personnel capacity available. A practical compromise is often necessary.

PERT/Cost cost development

Once the network has been established, based upon the project work breakdown, costs can be estimated. If the breakdown has been made satisfactorily, it will serve as both an estimating and actual cost accumulation vehicle. The proper implementation of PERT/Cost, like budget-

[3]*Ibid., p. 28.*

ing, must rest upon active participation by the responsible executives. This was recognized by the NASA/DOD PERT/Cost Guide when it was recommended that the operating and management personnel develop the cost estimates for each work package.[4] As with budgeting, any accounting work during the estimation period would be of co-ordinating nature.

The development of the cost estimates must rest upon a sound philosophical basis consistent with management needs. Presently there are four approaches to developing the cost estimates: (1) a single cost estimate of expected actual cost; (2) three cost estimates combined by formula into expected cost; (3) optimum time-cost curves (used in construction industries and by NASA/DOD Resource Allocation Procedure Supplement); (4) three separate cost estimates (used in the NASA/DOD Time-Cost Option Procedure Supplement).

Each of these theories of PERT/Cost estimating has as its goal the assigning of the best cost estimates possible to the network. Yet each offers the manager separate, distinct planning capabilities.

A single cost estimate of expected actual cost is based upon the summation of the cost elements. These estimates are first made by determining the manpower, material, and other resources required to complete each work package. The estimates for the direct costs applicable to the network activities are expressed in terms of expected dollar expenditures. Indirect costs may then be allocated to the individual work package or added to the total cost of the project.

The three-cost-estimate approach has as its goal the determination of the "expected cost." The advantage of the three cost estimate over the single cost estimate is that the result is subject to probability analysis. The formula combines an optimistic, most likely, and pessimistic cost estimate. The mean cost for each activity is calculated by the formula:

$$C_e = \frac{C_P + 4C_L + C_O}{6}$$

where C_P is the pessimistic estimate, C_L is the most likely cost, and C_O the optimistic estimate. The standard deviation of the cost distribution can insert probability into the analysis. With this expected cost, the manager cannot necessarily assume that he has the optimum cost-time mix. However, if the cost estimates are realistic, the probabilities of achieving the expected cost can be used for project negotiations.

A third approach to cost estimates is the optimum time-cost curve concept. This is differential costing with time as the factor of variability.

[4] *Ibid., pp. 109-113.*

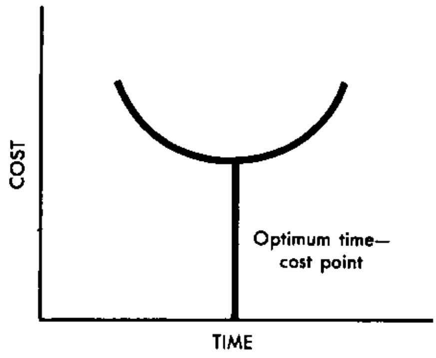


Figure A

The intention of this approach is to optimize time and costs by using optimum estimated costs. It assumes there is a direct relationship between time and costs on any activity. This relationship can be expressed by a continuous curve. If a cost curve can be developed similar to Figure A, many insights can be gained. Network schedules can be modified to obtain the lowest cost commensurate with the customer's delivery desires. Other questions can also be anticipated—questions such as: How long will completion take with a fixed budget? What will the costs be to complete the project within a given time period? In theory this concept is undoubtedly superior to either the one or three formula estimates, but without complete historical cost data the development of this curve is impractical.

Because the development of continuous time-cost curves for all activities is extremely difficult, if not practically impossible, the Resource Allocation Supplement to PERT/Cost was developed. This supplement is a variation of continuous time-cost curves which can be used in planning a small group of *significant* activities representing only a minor portion of the overall project. This method is also based upon the concept that activities are subject to time-cost trade-offs. The steps of this procedure are shown in the diagrams in the illustration on page 257.

Another alternate to overcome the practical problem of the continuous cost curve is a linear function based upon two time-cost relationships. The cost and time expenditures are forecast for two conditions: normal and crash. The normal point is the minimum activity cost and the corresponding time. The crash point is defined as the minimum possible time to perform the activity and the related cost. A linear function is

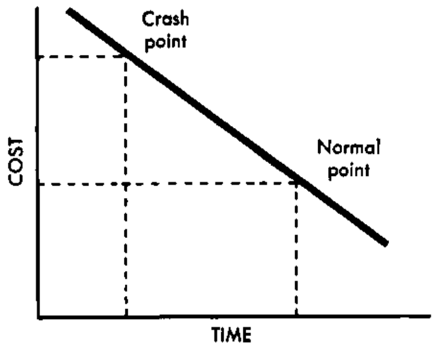


Figure B

assumed to exist between these points. Figure B shows this graphically. This method is similar to the high-low point method of fixed and variable cost determination and suffers from the same type of criticism.[5]
The problems of realistic estimates, discretionary costs, stair-stepped cost functions, incorrect correlation between time and cost, and external factors are continually present. It is justifiable due to its relative simplicity when the element of nonpredictable error can be permitted. A simplified, but typical usage is shown in the illustration on page 259.

The NASA/DOD PERT/Cost Guide presents a time-cost option (called the Time-Cost Option Procedure Supplement) based upon three time estimates. The single estimate of expected cost and the three-cost-estimate formula methods do not indicate whether there may be a substantially more efficient alternative plan. The continuous cost curve concept provides these data,[6] but requires considerable sophistication in cost analysis, or else, considerable supposition. The time-cost supplement recognizes that a sing'e estimate will normally be used for contract proposals and that additional data are needed to provide information as to the amount of time that might be saved by spending more money or the amount of money that could be saved by extending the contract time. The three time estimates used are:

✓*The most efficient plan.* This is the network plan that will meet the technical requirements of the project utilizing the most efficient use of present resources. This is the plan that would be chosen without budget and time constraints.

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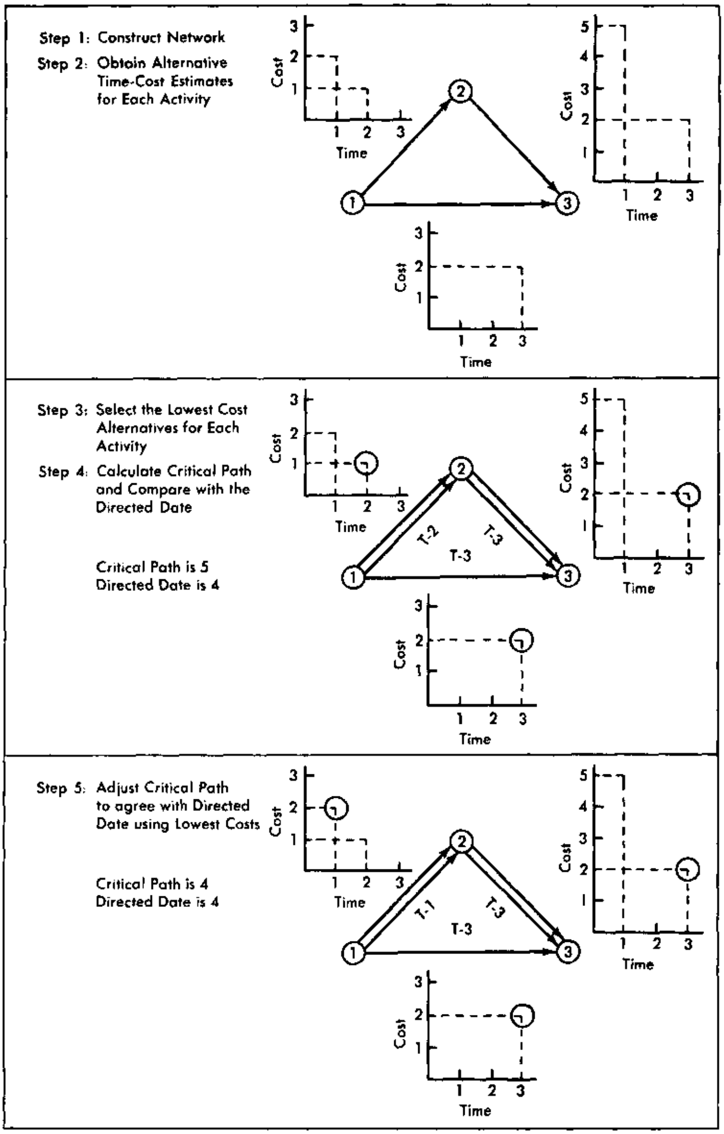
[5]*Glenn Welsch, Budgeting: Profit Planning and Control, Prentice-Hall Inc., Englewood Cliffs, N.J., 1957, pp. 173-174.*
[6]*See Figure A on page 255.*



A Summary of the Resource Allocation Procedure

In the Resource Allocation Procedure, we can determine how to accomplish a project by a specified date at minimum cost. The critical path here is the path from Event 1 to Event 2, and from Event 2 to Event 3 since this will require five days at absolute minimum costs. But the Directed Data for completing the project is four days from its beginning. Thus, from the time-cost chart, we find that we can cut the time between Events 1 and 2 to one day, but we double the cost of this activity. Since shortening the time of the second step in the critical path would cost more, however, we choose to reduce time of the first step to one day.

The directed date plan. This is the network plan developed to meet the technical requirements of the project by the specified completion date.

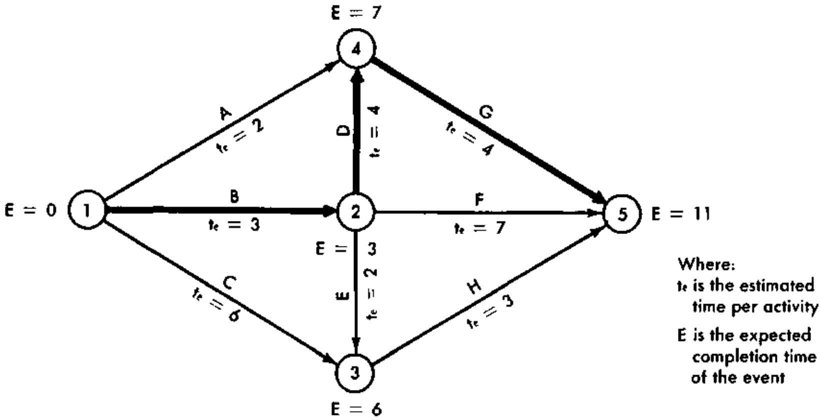
The shortest time plan. This is the network plan that will meet the technical requirements of the project in the shortest possible time.

Since the desired plan is the most efficient plan, any study should begin there. This most efficient plan must then be modified to achieve the project's objectives by the specified date. The most efficient plan when altered to attain the desired delivery date becomes the directed date plan. The directed date plan is then revised to obtain the shortest time plan. The work packages that have not changed in evolving the alternate plans will utilize cost estimates for the most efficient plan. New cost estimates will be necessary only on those work packages that are expected to increase or decrease because of the modifications. With three estimates on these work packages, the customer is apprised of the impact of his decisions during negotiations. Once the customer has made his decision, the appropriate cost estimate can be assigned to the network.

These cost estimating techniques represent the current approaches to computing forecasted costs. When coupled with a sound approach to determining the project work breakdown, forward planning is definitely facilitated. To this point PERT/Cost is a planning tool, but the loop between planning and control is not closed. For control there must be comparisons of actual cost expenditures with those estimated during the planning stage. The accountant must play an active role when the loop is closed between the planning and control phases. The generation of feedback data consistent with the planning stage calls for a chart of accounts correlated to the PERT network.

The PERT/Cost challenge

The accountant is charged by management and society with providing financial information for all levels of decision making. If the accountant is to serve the managers effectively, he will have to broaden his influence beyond the confines of historical data to include all areas of the firm and the future. PERT/Cost offers him one challenge in this direction. It can be seen that if PERT/Cost can be co-ordinated with PERT/Time, the manager has an excellent tool for project planning and control. In addition to financial reporting both on the total cost level and the individual manager's level, it offers distinct opportunities for decision making during both the planning and control phases.



An Illustration of Normal-Crash Procedure

The critical path of this network is eleven days. To accelerate the program one day, activities B, G or D must be condensed one day. Based upon cost curves computed on a normal-crash basis, the table of costs below is available.

Activity	Normal		Crash		Acceleration Cost per Day
	Days	Cost	Days	Cost	
A	2	80	1	130	50
B	3	70	1	190	60
C	6	110	5	135	25
D	4	60	3	100	40
E	2	90	1	100	10
F	7	85	6	115	30
G	4	105	3	175	70
H	3	50	2	70	20
Totals		650		1015	

Since Activity D costs \$40 to accelerate whereas Activity G costs \$70 and Activity B, \$120, accelerating Activity D is least expensive. The total cost of completing the program in ten days is \$690 (\$650 + \$40). By compressing the project one day, Activity F enters the critical path. To accelerate the program to nine days the following activities could be reduced: G and F at a total cost of \$100 or B at a cost of \$60. Therefore, for the reduction to nine days the cost would be \$750 (\$650 + \$40 + \$60).

The discussions here might lead one to believe that PERT/Cost offers no problems. Unfortunately, this is not the case. Despite the potential there are basic problems. An enumeration of some of these problems would include:

1. PERT/Cost for decision making in optimizing costs requires a sophistication of cost analysis that is not possessed by some firms.

2. There is a lack of historical information for assigning costs to networks since the concept is new.

3. There is difficulty in making project costs compatible with fiscal practices.

4. The problems of overhead charges, joint costs, and incompatibility of the organizational cost flow with the functional flow are numerous.

5. There is a problem of reconciling the "jobs" that are using PERT/Cost with those that aren't for fiscal reporting.

6. The personnel and machine capabilities are not always available.

7. Cost accumulation for financial stewardship reports can conflict with the cost centers for PERT/Cost and can therefore create redundant systems.

8. The conversion of project oriented costs to mesh with annual budget concepts requires additional analysis.

If the problems associated with PERT/Cost can be resolved, PERT with COST could be considered a major breakthrough as was PERT with TIME. The majority of the potential problem areas with PERT/Cost lie in the controller's department. These difficulties present a very real challenge to the controller. PERT/Cost is putting the adaptability of the accountant to the test.

GRANVILLE R. GARGIULO

Statistical Sampling

MANY COMPANIES' price schedules are veritable mazes of quantity, cash, and other discounts. For the most part, these price differentials are assumed to reflect cost differentials. In practice, unfortunately, this assumption is not always valid, as a number of companies have found when they attempted to defend themselves against charges of price discrimination brought under the Robinson-Patman Act. All too many price differentials are based on trade custom, historical practice, or pure intuition rather than on thorough analysis of the actual costs of serving different customer groups.

Price differentials that reflect differences in the cost of manufacture, sale, or delivery resulting from differing methods of delivery or varying quantities sold to customers are both legal and economically sound. It might seem obvious that the time to analyze and justify these cost differences is at the time the prices are set, not after the prices have been attacked under the Robinson-Patman Act or after they have caused noticeable erosion of profits.

Yet few companies actually do analyze their costs in this way. The primary reason lies in the prohibitive cost of maintaining a record keeping system that would provide detailed enough data to support this kind of cost analysis.

There is, however, an alternative. As in quality control and other comparable areas of business, statistical sampling and related analytical procedures offer a reliable substitute for 100 per cent verification in validating the allocations and estimates needed to identify the costs applicable to different customers or classes of customers.

This article explains how statistical techniques may be used to establish the quantitative measures of direct and indirect cost variations per unit of product that are needed to evaluate cost differentials. A case example is used throughout to explain these techniques and to demonstrate their application to cost and price differentials.

A distributor of a standard machine replacement part has a price schedule offering quantity discounts. This schedule purports to reflect the cost reduction he realizes in delivering larger amounts of the part, which is packed in standard containers of one to three equivalent units.

The cost accounting system used by the distributor is soundly constructed and provides an appropriate cost picture for management purposes. However, the detail and continuity of record keeping are insufficient to generate historical costs that would substantiate the existing price schedule on a continuing basis. On the other hand, it would be uneconomical to initiate and maintain more detailed record keeping as a routine procedure. The distributor therefore decides to gather data on a selective basis to demonstrate the cost differences associated with serving accounts of different size.

Sales and deliveries are handled on a route basis. There are 100 routes, each serving five accounts. Each of the 500 customers is visited once a week, with a sale (and delivery) made about 50 per cent of the time. On an annual total of 5,000 route trips, 25,000 customer visits are made.

The principal costs of the route deliveries are wages paid for the time of the delivery men in loading trucks, driving the route, and unloading the parts. The output of this effort is the number of containers delivered to customers. Consequently, the cost reduction passed on to large-quantity buyers is believed to be directly related to the time saved per container in servicing such customers as opposed to smaller accounts. Thus, analysis must be conducted in terms of time, representing cost, and containers of parts delivered, representing the unit of work measurement.

The distributor decides to use statistical sampling for this study. For the benefit of those readers who are not already familiar with the basic principles of statistical sampling, this technique will now be briefly explained.

The aggregate or entirety of items about which information is desired is commonly referred to as a "universe" or "population"; in the case of the distributor it may be defined as 5,000 route trips. Sampling is the process of selecting a portion of this specified population in order to draw inferences about the population from it.

Statistical sampling embraces three distinct steps: (1) the determination of sample size based on a statement of the reliability requirements of the study, (2) the selection of the sample by completely objective methods, and (3) the evaluation of the results. Knowledge of the following basic terms is essential to an understanding of statistical sampling:

Random selection—Statistical sampling depends on the principle of random selection. Random selection means selection governed wholly by the laws of probability, where each item in a population being sampled has an equal chance for inclusion in the sample.

Sampling error—Random sampling methods make it possible to estimate in advance the sampling error that will result solely from the use of a sample. This estimate is an indication of how close, with determinable probability, the sample characteristic being measured will be to the actual characteristic of the population.

Reliability statement—The extent to which the difference between the sample result and the population value is controlled is expressed in a reliability statement. The degree of sampling precision, represented by sampling error, is a specific value added to and subtracted from the sample result. The range created by this addition and subtraction is called a confidence level and is one part of the reliability statement.

For example, suppose that the distributor desired to determine the average order size for a class of customers. If the sampling precision is estimated at 2 per cent and the average order size for a randomly selected sample of customer orders is 500 containers, then the average order size for all store accounts is, with measurable probability, within the confidence interval of 490 and 510 containers.

The other part of the reliability statement is the degree of certainty or probability that the population characteristic will lie within the confidence interval. When we speak of a 95 per cent assurance that the average order size for all accounts will lie within 490 and 510 containers, we mean that there is a 5 per cent chance, or one chance in twenty, that the average will actually fall outside this interval. Consequently, the selection of the assurance level used in the reliability statement reflects the risk assumed of having the population value lie outside the confidence level.

The reliability statement is the key to the interpretation and use of facts derived from sampling. The level of assurance and degree of precision required should be decided by considering what the resulting confidence interval means in terms of its effect on the acceptability of the results. In interpreting the confidence interval, however, the interdependence of the assurance level and the confidence level in the reliability statement must be recognized.

By way of illustration, consider the previously mentioned sample, which provided a 2 per cent confidence interval and used a 95 per cent assurance level. For the same sample, other assurance levels would result in different confidence intervals as follows:

Assurance Level	Confidence Interval
80%	±1.3%
90%	±1.7%
99%	±2.6%
99.7%	±3.0%
99.99%	±4.0%

As this example shows, for the same sample the higher the assurance level taken the wider the associated confidence interval will be. Wide confidence intervals, however, may be considered detrimental to a demonstration of true cost differentials. It is possible, of course, to increase the reliability by increasing the size of the sample taken. Yet to reduce the confidence interval by one-half, the size of the sample must be quadrupled; to reduce the confidence interval to one-fourth its original size requires about a sixteenfold increase in sample size. This relationship must be kept in mind in evaluating the cost and feasibility of larger samples.

Other sampling techniques

Statistical sampling is not, of course, the only means of taking a sample. It is, however, by far the best if results of measurable validity are sought.

Nonstatistical methods of sampling are of two varieties: judgment sampling and quasi-scientific sampling. Judgment sampling involves the selection of a subgroup of the population that is considered to be representative of the total population on the basis of the best available information. The distributor, for example, finding it impractical to extend the analysis over a year's time, might select a shorter time period that he considered completely typical—free of seasonal, cyclical, or accidental variances in volume of business, characteristics of distribution operations, or incidence of expense.

The need for applying such judgment points up one of the major shortcomings of this approach, namely, the need for considerable knowledge of the population and the subgroup selected—or for strong assumptions about them. The validation of such assumptions is likely to require research beyond the scope of most cost analyses. Another serious limitation of judgment samples is that the representativeness of the data from them cannot be supported through the application of acceptable statistical testing procedures. Nor can the reliability of the sample results, in terms of bias and variability, be scientifically determined or controlled.

Some of these deficiencies are overcome by the employment of quasi-scientific sampling. For example, while the period for study (which in our example provides a limited population consisting of all trips in that period) may be selected on the basis of judgment or conjecture, the actual sampling shares with statistical sampling the advantage of objectivity. same objective procedures used in statistical sampling. This makes it possible to calculate a measure of reliability of the sample once it has been drawn from within this limited population. Thus, quasi-scientific sampling shares with statistical sampling the advantage of objectivity. Proper selection procedures assure that the test will bring to light a reasonable cross section of the area of cost difference being examined.

The purpose of using any sampling procedure, of course, is to obtain the needed information with a minimum expenditure of time and money. Such economy is of questionable value, however, if the results obtained are unreliable or if their reliability is unknown. No measure of reliability is available in judgment sampling. In quasi-scientific sampling the reliability is indeterminate until the sample is drawn.

Statistical sampling, on the other hand, permits measurement of the reliability and degree of assurance that can be placed on the results. By providing, in advance, such measures obtainable with varying sample sizes, statistical sampling makes it possible to select the smallest sample that will yield the reliability needed to justify cost allocations and the resultant price differentials.

The distributor, now armed with his new-found knowledge of sampling theory, is still confronted with some practical considerations. In order to keep the costs of his investigation within reason and to have better control over the conduct of the study, he selects one regional warehouse (Warehouse A) for analysis. This warehouse has 20 routes. He also decides to extend the study over a full year's operations. The consequence of these decisions is that a smaller population is defined, namely, "1,000 trips from Warehouse A" (20 routes/week × 50 weeks).

Without prior experience in analyzing areas of cost differentials, the distributor is unable to estimate in advance the variation and, consequently, the sampling errors that can be expected in any sample evidence. Therefore, he cannot apply any statistical formula for determining the sample size that will give him the reliability he requires in his sample results. As an alternative, he proceeds in the following way:

1. He takes a random sample of route trips and customer visits to obtain observations for some portion of four weeks' activity of Warehouse A.

2. He performs a statistical analysis of the resultant data and calculates the variation in the sample data.

3. Based on the assurance level desired, he evaluates how much he needs to cut down on the potential errors in the sample evidence to meet his criteria for acceptable cost differential statements.

The distributor may arbitrarily decide to obtain 20 observations of route trips. Warehouse A normally has 80 trips in four weeks. A table of random numbers is used to select the first 20 numbers under 80. These numbers represent the trips to be observed, e.g., 10th, 64th, 3rd, 8th, 30th, etc. (A sample of customer visits can be obtained by randomly selecting, from each trip selected, any number from 1 to 5 representing the number of accounts serviced per trip. Since the distributor is interested in unloading time, he can choose two random numbers from 1 to 5 for each trip, based on his experience that only 50 per cent of the time will a visit include a delivery of a part.)

The type of statistical analysis performed by the distributor is discussed in the following paragraphs. This analysis is performed on both this limited sample and the total sample eventually taken. The number of additional observations to be taken beyond this limited sample is determined as part of the last step previously outlined.

Correlation analysis

The distributor's objective is to use the sampling procedure to generate observations of different factors which might have some direct or indirect bearing on cost or the measure of effort representing cost (in this case, time). Some elements of time, when analyzed in terms of output of effort, are clearly assignable to the customer being served. For example, the time of a delivery man taken to unload ten containers of parts at a customer location is directly allocable to that customer. The cost differentials may result from the fact that the time requirement per case can be expected to decline (at perhaps a diminishing rate) with larger volumes per delivery, thereby lowering the cost of servicing high-volume customers.

In servicing customers, there are many other elements of time incurred by the delivery man that cannot be attributed to specific customers. However, since these costs constitute part of the total cost differential they must be applied on appropriate bases to the classes of customers under consideration. The statistical technique for relating observations of other factors or variables in delivery activity to the sample observations of indirect time elements involves the use of correlation analysis.

Basically, this analysis involves the establishment of some assumption as to which variables might affect the indirect time elements, a subsequent statistical test of the significance of these assumed relationships, and a quantification of the relationships as a basis for allocating costs. As an example, the distributor may logically believe there is sufficient relationship between the time spent by the delivery man in loading his truck and the number of containers he loads to justify using volume as a basis for allocating loading time (and related cost) to customers. For each trip in the sample, observations are obtained on the total number of containers loaded for that trip and the total time required to load the truck.

The first step is to obtain a measure of the relationship between these two variables. If the distributor's intuition is sound, we would expect to find that as more containers per trip are loaded, the delivery man spends more time in the loading activity. These two variables would be said to be positively correlated. The calculated measure of this relationship is referred to as the "correlation coefficient," which expresses the degree of association in terms that are independent of the units of the original data. The correlation coefficient can have a maximum value of 1 (perfect positive correlation) and a minimum value of -1 (perfect negative correlation). Zero represents perfect independence in the two variables.

If the correlation coefficient between loading time and volume loaded was $+0.95$, this would indicate that there is a high degree of association between the paired variables and that as one variable increased the other would also increase. Since the correlation coefficient is a relative measure, one coefficient can be compared with any other. Consequently, it is possible to check on other variables that might have an association with loading time to give assurance that the selected variable is the best (has the closest association) we can obtain as a basis for cost allocation.

Having determined the value of the correlation coefficient, it must be determined whether or not the apparent relationship between the paired values, as developed from a sample, is not attributable solely to chance and is truly indicative of the relationship of these variables in the population. In other words, we must determine how likely such an estimate is to be obtained if the true population coefficient has some specified value. Methods are available to test the significance, at a stated probability level, of the correlation coefficient. The essence of the test is as follows:

1. Make two suppositions: first, that there is no correlation in the

population and, second, that there is a correlation in the population. (The first supposition is called the "null hypothesis" since it is this hypothesis that the testing procedure is designed to nullify or support.)

2. State the significance level of the test, that is, the acceptable chances of getting a correlation coefficient as calculated from the sample if, in fact, there were no correlation in the population.

3. Select from the appropriate statistical table the value of the correlation coefficient associated with a given significance level and sample size.

4. If the sample correlation coefficient is less than or equal to the one from the table, then the null hypothesis is accepted, that is, the correlation coefficient is not significant. If the calculated correlation coefficient is greater than the coefficient from the table, then the null hypothesis is rejected (the alternative accepted).

Suppose the distributor, from a sample of ten route trips, computes a correlation coefficient of .72 between quantity loaded and loading time. He decides to test the significance of this calculated coefficient at the .05 level (five chances in 100 that .72 would result from a sample when there is no correlation between these two variables in the population). The value from the table indicates a correlation coefficient of .63. Since the calculated coefficient .72 is greater than the table value .63, he rejects the supposition that no correlation exists in the universe and concludes that there is evidence of a significant correlation.

Once satisfied that volume loaded has a significant effect on the loading time and that no other variable has an association with loading time, the distributor needs to describe the relationship between these two variables in a way suitable as a basis for allocating costs to customers. The calculations may be performed in a number of ways, but the end product is a regression or estimating equation, representing a given curve, which permits us to make estimates of the dependent variable (load time) for specified values of the independent variable (volume loaded). In our example this might take on the form of a straight line relationship expressed as: Load time (estimated) = 10 minutes + 1.2 minutes × number of containers. This equation indicates that 10 minutes were required for activities not related to volume (placing truck at dock, general paperwork, etc.) and that load time varied (in the sample) in relation to volume at the rate of 1.2 minutes per case. The average number of containers for a given customer class can then be substituted in the equation as a means for estimating the average time required to service a customer of given size on the basis of 1.2 minutes per case plus an appropriate share of the fixed loading time of 10 minutes.

The use of estimating equations is not limited to indirect time elements where cost allocations must be made. As a practical matter, price differentials for different customer volume levels are based on average volume and average costs over a period of time. Consequently, it is desirable to develop estimating equations for directly attributable cost elements (e.g., time spent in unloading containers for a given customer) which would yield results more reliable over time than those directly observed in any study period of limited duration.

In the case of unloading time, the estimating equation is itself a measure of the average relationship of all sample observations of unloading time versus quantity delivered. The equation yields for practical use the most likely unloading time required for delivery of specified quantities. By specifying delivery quantities, the equation can be used to compute the loading time; this computed time represents a characteristic of the population which reflects the separation of systematic factors affecting unloading time in a regular and predictable way from chance factors that are irregular and unpredictable and distort studies based upon restricted samples.

Inasmuch as the methods of statistical sampling are used to generate the observations of the paired variables upon which estimating or regression equations are developed, the reliability of the relationship is determinable and may be interpreted in the following way:

Sample observations of randomly selected customer visits are used to develop a regression equation relating unloading time (T) and quantities delivered (Q). This equation is $T_{est.} = 15$ minutes + 1.5 minutes $\times$ Q.

A measure of the random sampling errors in using the regression equation as an estimator of the population average unloading time for any quantity delivered is developed. From the sample this measure equals 10 minutes at a 95 per cent confidence level.

For a delivery of 20 containers we substitute in the above equation to obtain an estimate of 45 minutes as the average amount of time required to unload this quantity.

From our knowledge of the sampling error, we can make statements of the following type (similar statements could be developed for different confidence levels):

1. "The probability is 95 per cent that the interval 35-55 minutes will include the population value of average unloading time for 20 containers."

2. "There are 5 chances in 100 that the true average unloading time for 20 containers will be greater than 55 minutes or less than 35 minutes."

One further use of the estimating equation might be mentioned. In the case study previously outlined, the distributor conducted his analysis on the operations of Warehouse A. However, his price schedule is the same for all customers (excluding freight costs from the manufacturer to the warehouse). To ensure the universal application of his basis of cost allocation in all distributor regions, the distributor could take a restricted (and much less costly) statistical sample of delivery activity at other warehouses. Actual quantities loaded and delivered could then be substituted in the regression equations developed from the study at Warehouse A to obtain estimates of time to carry out this activity. These estimates could subsequently be compared with the actual times observed. The measurable variation between estimated and actual times required could serve two purposes: first, to further confirm the validity of the estimating equations developed as a basis for cost allocations and, second, to demonstrate the general applicability of the equations, thus enabling the distributor to avoid the incurrence of re-incurrence of the high cost of conducting such studies in every distribution region.

Occasional special studies of cost differentials executed in accordance with accepted statistical and other analytical principles can provide management with useful pricing guidelines at a cost well below that of maintaining detailed records on a continuing basis. Only the management that knows the cost of serving each group of its customers is in a position to set prices that truly reflect cost differentials.

Furthermore, the company that conducts such studies has a good head start if the need should ever arise to justify its price differentials under the Robinson-Patman Act. Substantially all cost justification defenses in court proceedings since the Robinson-Patman Act was passed have involved the use of sampling in the cost data presented. In certain cases the cost defense was weakened, not because the supporting statistical techniques were unsound but because it was not proved that the samples selected were truly representative of the seller's operations.

Because of their demonstrable objectivity and lack of personal bias and because of their measurable reliability consistent with reasonable expense, statistical sampling, correlation analyses, and regression or estimating equations provide a reliable basis for allocations and estimates. While the acceptance of statistical techniques as legal evidence is currently unclear, a perusal of Federal Trade Commission proceedings in Robinson-Patman Act cases seems to indicate that the techniques as such are clearly recognized and accepted by the authorities as a basis for cost analyses and a means of specifying the reliability of the analyses in statistical terms. Consequently, there should be no hesitation to expand the use of statistical techniques to lend support to the data being presented in cost justification defenses.

CHAPTER

9

The Total Information Concept

Advanced EDP Systems –
The Total Systems and the
Single Information Flow Concepts

Designing a Fundamental
Information System

A. F. MORAVEC

Advanced EDP Systems – The Total Systems and the Single Information Flow Concepts

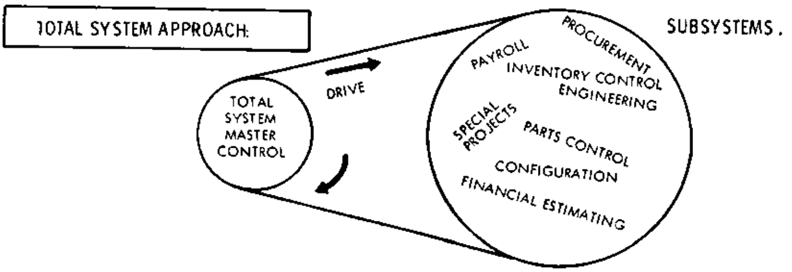
DEVELOPMENTS in digital transmission, the availability of faster bulk storage devices, and the use of man/machine interface devices such as display equipment and interrogation consoles have stimulated a new kind of data processing. In this processing, information is entered into the system as it is generated 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.

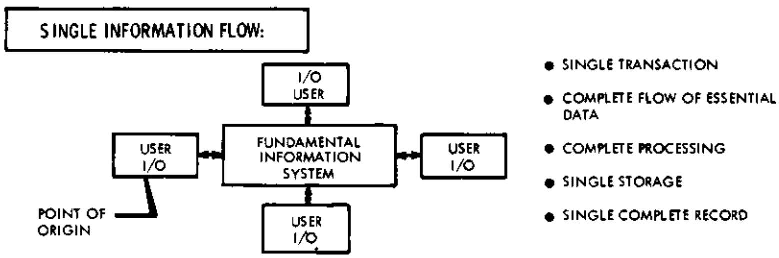
To take full advantage of these technological advances, management must abandon the hit-or-miss approach that has hitherto characterized much of its use of computers and develop a basic data processing philosophy. A reliable management information feedback system cannot be achieved without well defined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

The total systems approach is the logical final goal of many com-

Exhibit 1





panies' 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 integrated (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

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

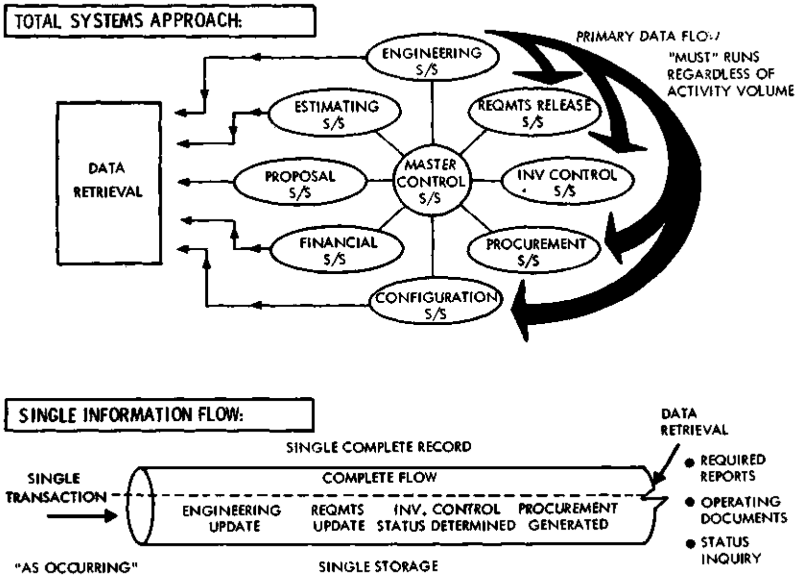
in its history; from then on it is available to serve all requirements until its usefulness is exhausted.

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 cus-

Exhibit 2



tomer information; the bank book plus cash drawer gave him his cash balance; and accounts payable were visible on 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.

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 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

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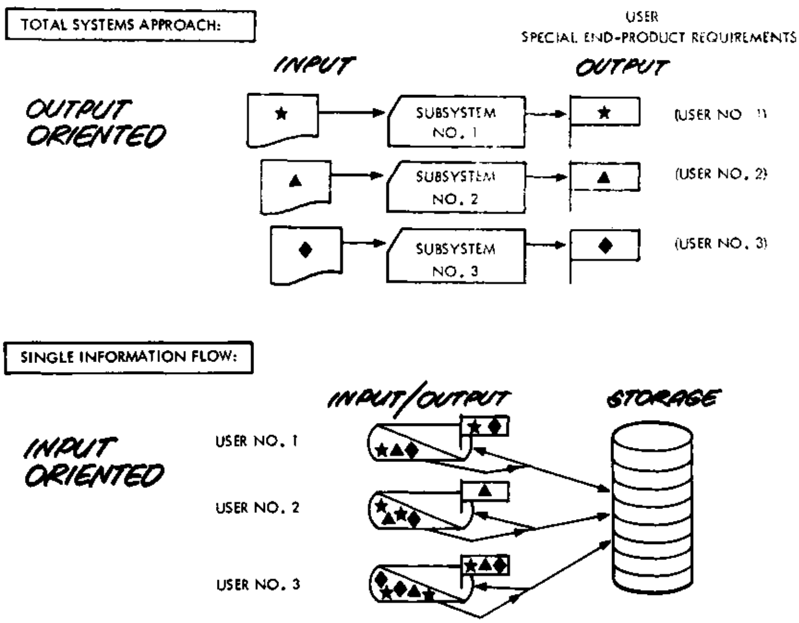
[2] *Gregory and Van Horn, Automatic Data Processing Systems—Principles and Procedures, 2d ed., Wadsworth Publishing Company, Inc., Belmont, Calif., 1963.*
[3] *Ibid.*

Exhibit 3



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 "fun-

[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.*

damental" 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 direct 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.

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 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]

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

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.

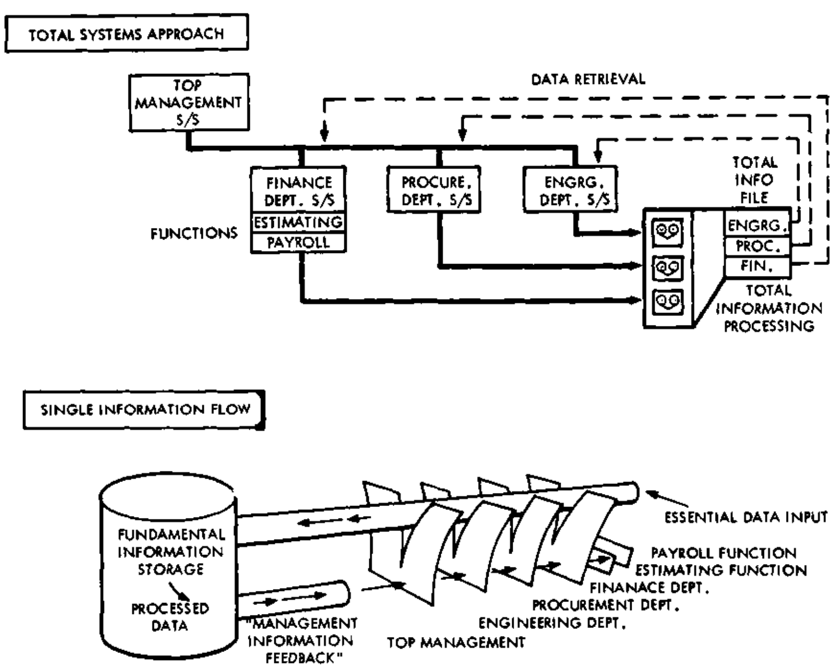
Individual user files will not be maintained. Instead, there will be a single record file accessible to all users. Nonessential data and data not needed to update records will be processed directly through cross talk between users point-of-origin devices. Such data could be documented if need be through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

Pros and cons of both concepts

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

Exhibit 4



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.

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.

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, cost 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 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.

Which system?

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.

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.

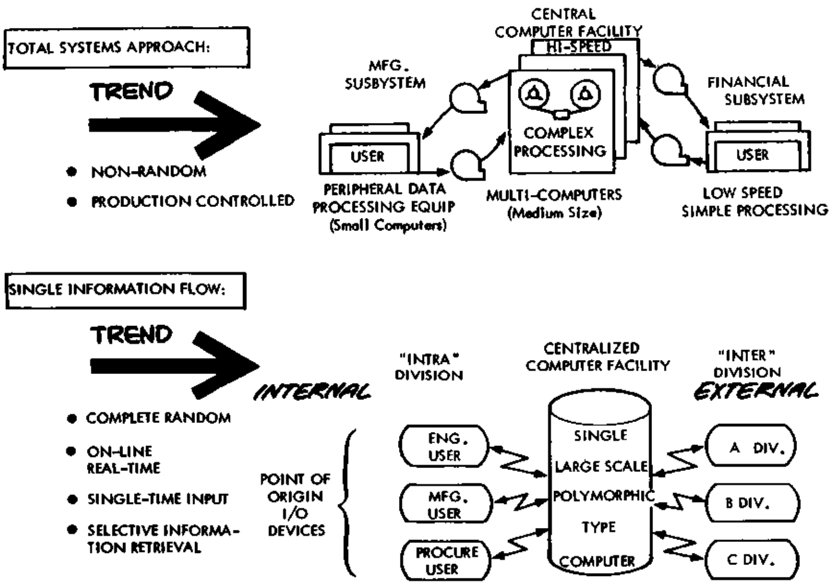
The present concept of business systems engineering has evolved over a number of years. In the early years of computer technology the components (subsystem) approach prevailed. At that time an integrated business information system was thought to exist if a business transaction element was introduced 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.

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 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 ana-

Exhibit 5

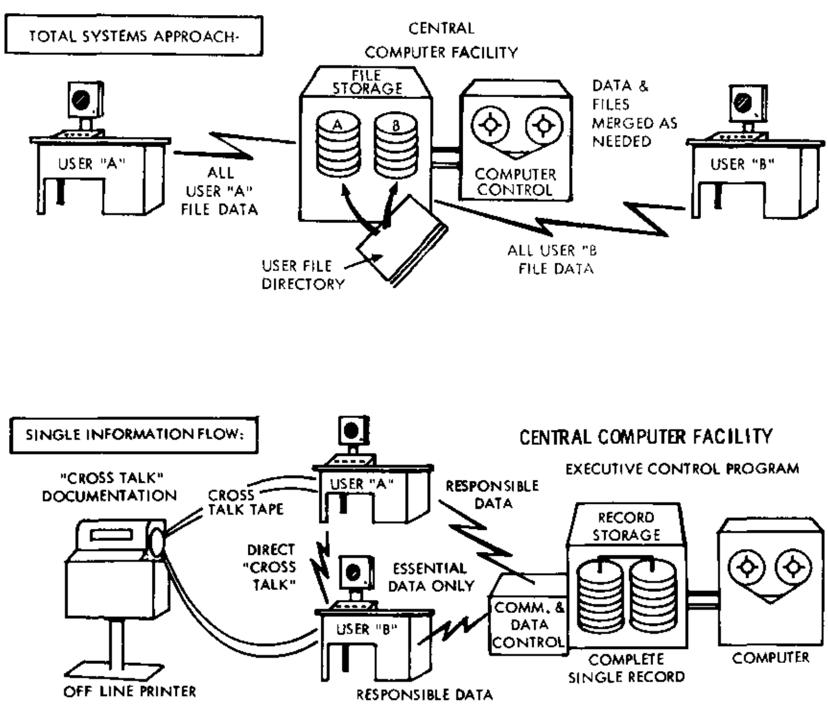


lyzing company processes in a way that will permit mechanization of data elements at their source. The reason has been not only a desire to perpetuate the data in their original form but also the need for integrating the overall process and developing a truly realistic fundamental information system.

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.

Exhibit 6



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 "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.

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.

A. F. MORAVEC

Designing a Fundamental Information System

ANALYZING a corporate data system is still a primitive process. Although the computer has revolutionized data systems in the past decade, there has been no corresponding revolution in the procedures for installing and operating them. The rationale for determining what data to analyze and how to go about it and the basic techniques for interviewing, documenting, flow charting, and analyzing have changed little since the advent of the computer. Indeed, they have not changed greatly since the nineteenth century.

The large size, complexity, and variety of modern data systems cause continuing difficulties for the systems analyst. Two to eight years, depending on the scope of the application, can elapse from the initiation of a data systems study to its implementation. During this period the systems analyst is beset by continual pressures to get the system operating. Meanwhile, policy changes and personnel rotation are playing havoc with the systems planning.

In general, four major problems handicap present-day systems analysis: (1) a large workload, (2) a long span of elapsed time, (3) a lack of explicit directions both for conducting the study and for using the results, and (4) the lack of a technique to control changes in the data system throughout its life.

These problems are far from being solved. Some new techniques, however, offer promise of alleviating some of them. Data network analysis, which incorporates a method of using the electronic data processor to prepare many of the systems analyses automatically, reduces the total workload and the time span from inception of a study through the preliminary phase. Source input/output analysis facilitates development of the essential information that each functional group within the company needs to operate efficiently. Simulation permits study of the operation of the information system in the form of a model.

This article describes these techniques and explains how they can be applied to the design of an information system, specifically a so-called fundamental information system based on the "single information flow" concept of data processing.

An information system may be defined as the procedures, methodologies, organization, software, and hardware elements needed to insert and retrieve selected data as required for operating and managing a company. In this article no distinction is made between so-called management information systems and other kinds of information systems. The term is used to include all specific data required to conduct the business of the company regardless of whether the data are classified as operating, management, accounting, or any other kind of data.

In many companies the information systems are systems by courtesy only. In the early days of computer technology the components or subsystems approach prevailed. An integrated business system was thought to exist when pieces of information were introduced into the information flow and perpetuated there with a minimum of manual intervention. Mechanization of existing operations—or of data for specific random jobs—resulted in a multiplicity of relatively static systems put together on a piecemeal basis.

Now there is a growing recognition that the interactions and interdependencies among components of a system are more important than the components themselves. Managements are beginning to realize that the information system must be integrated lest data processing become a giant papermill so complex in structure that it is impossible to control.

As Richard E. Sprague has pointed out,[1] fundamental economic and system pressures are fostering a management desire for clean and uncomplicated information systems. Economic pressures include the need for functional and geographic integration of data and the pressure for sharing of computer equipment by users. System pressures, based

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

on the desirability of carrying the processing of data to the user and in other ways making service to him more rapid and more meaningful, include the desire to mechanize data at the source; the need to solve the problems of sharing time on computers that operate on a batch processing basis; and the attractiveness of incorporating on line-real time data processing with current feedback of information to assist management in its decision making function.

These pressures do not operate on every company with equal force, of course. The organization that is considering the design of a new information system should first consider the following questions:

How satisfied are people throughout the organization with the existing input and output of information?

Have the most recent important changes in data processing operations—manual or computer—been fully "digested" as yet?

Have major new technical improvements in systems hardware and software recently become available?

Are operating management personnel receptive to new and important changes in the future?

Does the organization have designers with the skill and experience needed to develop a new information system?

Are the probable time schedules for such a project satisfactory?

Are financial budgets adequate?

Does the potential payoff justify the effort? Cost and benefit elements of both the present and the proposed system should be analyzed and compared. Exhibit 1 on page 290 lists the payoff elements normally considered.

If the design of a new information system seems worthwhile, the next question is, "What kind of information system?" As the previous article in this book pointed out, two alternative concepts are being proposed by data processing specialists today. They are the "total" information system, based on the "total systems" approach, and the "fundamental" information system, based on the "single information flow" philosophy.

The total information system, a logical extension of the present subsystems approach, is an attempt to unite all existing information subsystems in the company into a single integrated system. The intent is to include all data for all the needs of all levels of management and operations. Each piece of data is entered in each information subsystem that may need it, with multiple records of similar data as a result.

The fundamental information system, on the other hand, is limited to data considered absolutely essential to the operation of the company.

EXHIBIT I
SYSTEM PAYOFF

System Costs

Hardware:
- Basic processor
- Storage devices
- Peripheral equipment
- Communication equipment
- Facilities
- Input/output devices
- Equipment maintenance
  - Total

Operating Expenses:
- Program maintenance
- Equipment operators
- Media preparers (key punchers)
- Data collectors
- Data control and correction
- Utilities
- Cards, paper, etc.
  - Total

Development Cost:
- Hiring and training of programers and analysts
- Salaries
- Disruption of normal operations
- Retraining displaced personnel
  - Total

System Benefits

Decreased Operating Costs:
- Fewer people
- Less inventory
- Fewer penalties for late payment or delivery
- Lower transportation or purchasing costs
- Fewer shortages to interrupt production
- Better scheduling of production
- Better service (internal-external)

Other data needed for one reason or another by specific user groups are recorded and processed outside the fundamental information system. The fundamental data themselves are recorded only once and stored in a central location.

These two systems are compared in Exhibit 2 on page 291. Since the author considers the single information flow concept the most promising route to simple and efficient data processing, the remainder of this article will be concerned with the design of a fundamental information system.

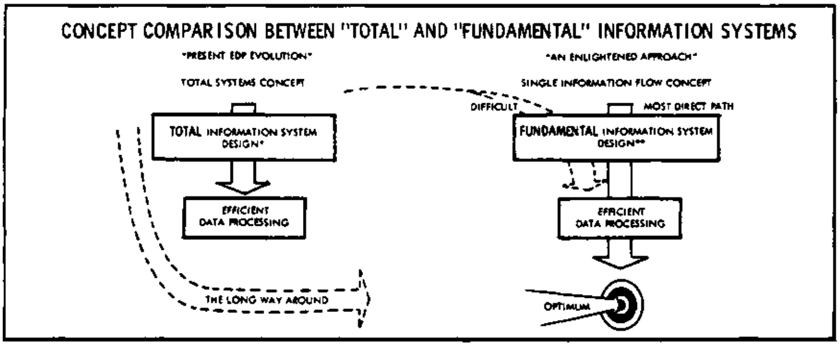
Design principles

The following generalizations represent principles[2] that should be kept in mind when designing the information system:

An information system is a system for supplying information to

[2] *R. J. Chambers, "The Role of Information Systems in Decision Making," Management Technology, Vol. 4, No. 1, June, 1964.*

Exhibit 2



FOUNDATION FOR:

"Total" Information System

1. Includes all basic interacting and interrelating data in attainable subsystems.
2. It attempts to satisfy all data requirements for all levels of management and for all operating needs.
3. All required or desired data will be included in the information data reservoir.
4. It is envisioned that this data reservoir or data bank will certainly be the larger of the two.
5. Record lengths will be smaller but the system will include multiple records of similar data.
6. Because of tradition and the desire to use what one already has developed, this kind of an information system will be difficult to construct. Many obstacles including complex data integration and handling will have to be hurdled.

FOUNDATION FOR:

"Fundamental" Information System

1. Includes only "essential" or "fundamental" data required to effectively operate the firm as a complete entity.
2. It satisfies only the basic data needs of the firm to accomplish its mission and provides the "selective" feedback information necessary for management decisions at its proper level and station.
3. "Nonessential" or "secondary" classed data desired by some operation or by some level of management will be processed off line by peripheral equipment and will not be included in the primary information data reservoir. (Until full conversion, most "secondary" type data will be processed in their present fashion as subsystems.)
4. It is envisioned that this data reservoir or data bank will be the smaller of the two.
5. Record lengths will be long and many, but only single records will prevail.
6. Since this system involves a completely new development approach, ties with the previous EDP environment are severed making this the most direct and hence the shortest path to the target of optimum data processing.

users who must take coordinated action. If effective communication is to take place, the language used must be such that response will be identified by all members of the organization. If action is to be coordinated, the information system cannot be treated as a group of independent subsystems.

The information system must remove all doubt about data, that is, the system must be so reliable that the user will depend upon it rather than upon his own observations. For example, information will fail to evoke response (decisions) relevant to the pursuit of its ends if it is found by receivers to be inconsistent with their own direct observations. In this case the system which produces the information will serve to increase rather than to reduce doubt; it will cloud rather than clarify issues confronting decision makers.

There is a point at which the marginal cost of differentiation of information and comprehensiveness of information exceeds the marginal utility of information to the received, i.e., an individual's capacity for making sound judgments about a complex situation may be seriously impaired by supplying him with a lot of information which he believes would be relevant but whose influence on the situation is not clear to him.

Thus, the information system is an abstracting system. Its justification lies in the reduction of the information available to the information that is relevant to action. But abstraction should not be carried to the point where differences in the significance of data are obscured.

An information system is a device for continually bringing under notice new facts and new knowledge. It must provide not only the premises of decisions but also a feedback so that decisions may be reaffirmed or abandoned in favor of others. The development of an organization and the development of the judgment of its agents alike depend on this feedback.

Since both the capacity and the time available for observation are limited, an information system must provide a formal record to guard against misinterpretation of past experiences. The records of an organization are its memory. Therefore, all records and communications at any time serve not only their immediate function but also the function of memory.

The information system must be regarded as a continuously developing instrument, in much the same way as an organization is constantly developing.

It is a matter of experience that information processing is done according to habitual modes far more commonly than according to deliberate assessment of the user's requirements.

For the fundamental information system to do its job properly, it must meet these requirements:

It must provide all the data essential to the operation of the company. These data should include both planning data and performance data. Performance data must measure both planned and present status and must indicate the probable future impact. Cost and financial data should be compared with budget or target dollars; operational schedules should be compared with planned completions; technical quality assurance data should be compared with established standards.

The system must be responsive to management needs. This responsiveness can be obtained by "designing in" the flexibility and adaptability needed to re-allocate resources as required. By means of computer simulations of management decision making requirements, for example, the type and frequency of changes in programs and resource allocations can be tested, and likely condition boundaries can be established.

It should be capable of "dynamic self-reprograming," i.e., able to reprogram itself to meet the ever changing demands of the company. (This is a part of the single information flow concept and its design.)

Systems analysis

To analyze the interaction of functions and departments using today's methods of operation and then to design the optimum system for mechanization using tomorrow's methods is a complex task involving complex human factors.

A completely new method of analyzing systems and describing information requirements is needed. It should fulfill two requirements:

For understandability and workability, the method should present the system in the form of a network in order to permit visual display of data dependencies and interactions, in order to pinpoint communication requirements (volumes, load, frequencies, stations, and the like), and in order to facilitate mathematical treatment (network theory, traffic or queueing theory, linear programing, PERT/Time/Cost, and the like).

The principle of data feedback must be incorporated in order to ensure the availability of those data required for management decision making and also to provide a basic structure for decision making simulation programs.

Two new systems analysis techniques are available that meet these requirements. They are data network analysis—for the synthesis phase of the systems study—and source input/output analysis—for the information-gathering phase.

Data network analysis[3] is illustrated in Exhibit 3 on page 295, Exhibit 4 on page 295, and Exhibit 5 on page 296. With this technique, data storage points in the system are analyzed and converted to single records as indicated in Exhibit 3, each record's characteristics, the activity in and out, and the data elements it contains are detailed.

With this method of analysis, the analyst prepares a flow chart of "event chains" and activities rather than of documents. In this way he can trace the flow of data and actions throughout a data network as they are created and as they respond to events instead of trying to categorize them into arbitrary segments of an information system under such nebulous labels as "applications." Exhibit 4 shows a simple data network; Exhibit 5 shows the same data network in conjunction with a computer communication network. One advantage of this technique is that the computer can be programed to prepare much of the initial systems analysis and documentation automatically.[4]

This data network methodology provides a visual representation of data and action dependency and interdependency, time sequencing of both data and action, load and volume analysis for communication and equipment purposes, and, as a by-product, automation of analysis and documentation. Using the computer to prepare systems analyses automatically—although it does not relieve the systems analyst of any of his usual analysis and design responsibilities—speeds up the preliminary analysis phase of the study and at the same time makes possible a more thorough analysis than can be prepared with present methods.

Determining records and data characteristics, volumes, relationships, and data storage needs gives the analyst a sound basis for design of a new data system. In addition, the data network analysis technique permits the tracing of data and their highly intricate chain reactions throughout the structure of the organization; in the process, user demand and users' effects on each other can be measured.

Because of the complexity of the task of defining a fundamental information system that crosses department lines and includes many functions, data network analysis should be preceded by source input/output analysis.[5] Assuming the systems designer has postulated that all information to be inserted into or withdrawn from the system

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[3] *Arthur D. Hall, A Methodology for Systems Engineering, D. Van Nostrand Company, Inc., Princeton, New Jersey, 1962.*

[4] *With some modifications, this technique is similar to Autosate, an automated data systems analysis technique developed by the Rand Corporation.*

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

by each point of origin (source) will be stored centrally and will be available on a real time basis as needed, the procedure for conducting input/output analysis is as follows:

The characteristics (functions, departmental mission) of each point of origin are identified. The true source of information generated at each point of origin (station) and the information required by each are described in detail.

Exhibit 3

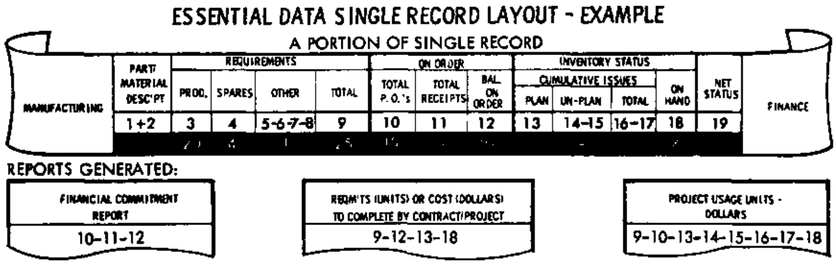
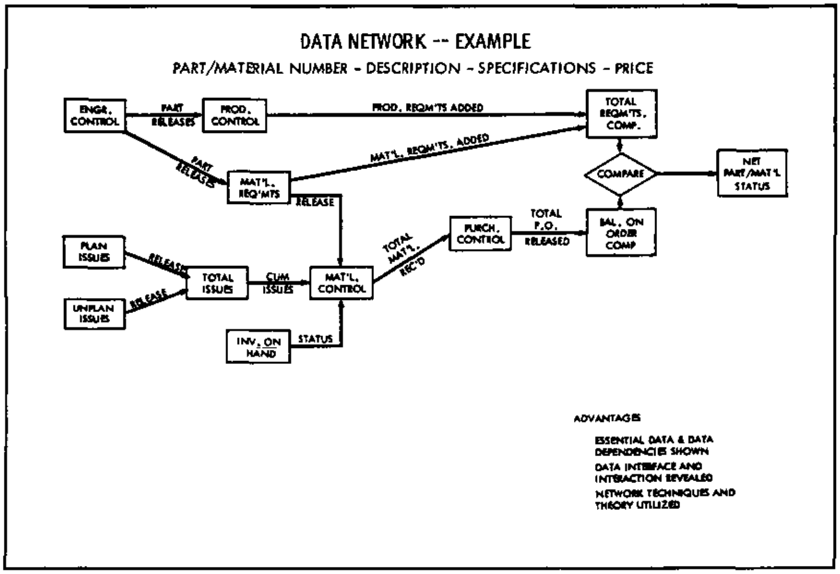


Exhibit 4



The information that must be held in central storage to satisfy all operating and management requirements is specified in detail. For management-type information a set of decision rules based on the objectives, policies, and procedures of the organization is inserted into central storage.

For comunication purposes, the message formats and lengths for transmission to and from each point-of-origin central point are defined. In addition, the information volumes, i.e., the number of messages per hour for each hour and for each point of origin, are estimated.

The sum total of all information generated, stored, and processed for each point of origin and each communication channel and for the central computer location is computed.

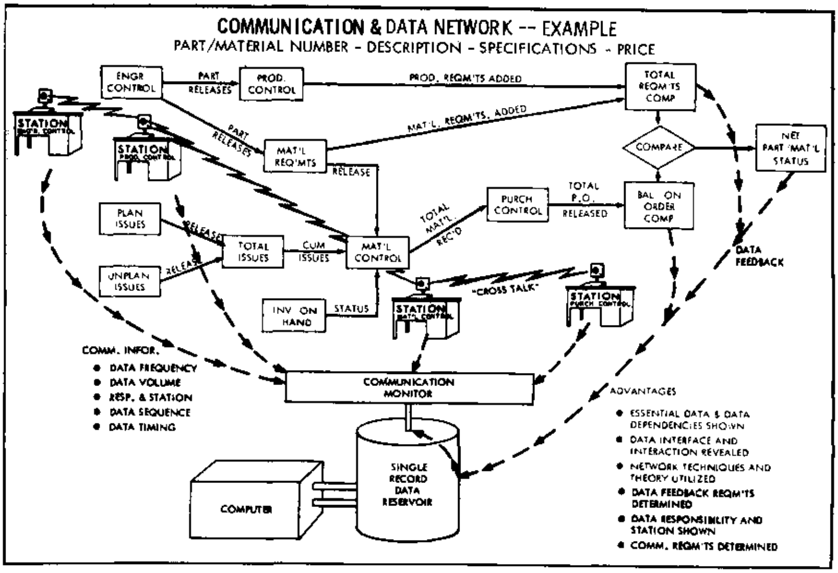
These data are then placed on a network for the synthesis phase of the systems study.

The basic steps in designing the information system may be summarized as follows:

1. Determine management's needs to monitor the enterprise as a whole.

2. Design the fundamental information flow, indicating the relation-

Exhibit 5



ships among the major functions and data, for example, engineering, manufacturing, procurement, 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 each function's dependence upon other functions' actions and/or information.

Administratively, the plan for conducting the systems study breaks down into three time phases. The first phase, investigation, consists of construction and testing of a simulation model of the system and of source input/output analysis. The second phase, that of preliminary design, includes merging and synthesis of the information gathered in the first phase, preparation of a composite data network analysis, complete initial design of the overall system, and design and testing of a workable automated system. The final phase, final design, consists of complete initial design of system details, selection of equipment configuration, and preparation of a plan for implementation of the information system.

Investigation phase

The initial investigation—the first phase—calls for a simultaneous two-pronged attack. One group, composed of operations analysts, is responsible for preparing an information system model with a resultant computer simulation model. This process is illustrated in Exhibit 6 on page 298.

Simulation is a technique whereby a system and its associated sequence of events are reproduced in the computer, that is, the computer is made to act like the system being studied. These simulation programs are usually referred to as "models" since they are representations of the real system.

At the same time another group, composed of systems analysts, is responsible for preparing an information system based upon review and analysis of present operations, subsystems, and data flows. Using the source input/output systems analysis approach, they determine and define "essential" data and secondary data, review present subsystem applications, prepare a network indicating data dependencies and interactions, design a single-record layout and data flow processing scheme, prepare preliminary conversion specifications, prepare a data and communication network flow, and prepare and assemble documentation.

Both groups must operate under the same systems objectives, goals, and criteria. These are established early in the study and revised as required. Examples follow:

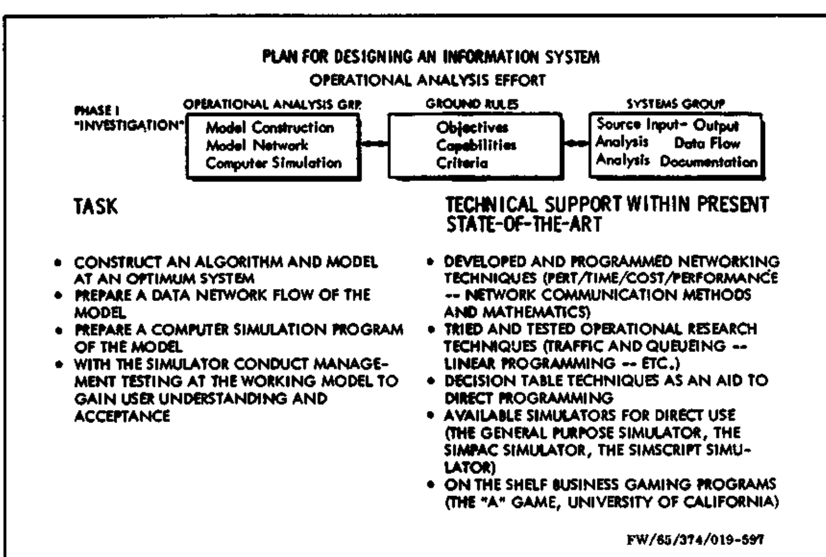
Objectives. Determine management's needs to monitor the whole enterprise. Provide for single-transaction and complete processing of "essential" data and complete single records and data storage.

Capabilities. Include planning and performance data within single records of essential data. Provide for timely responsiveness to dynamic management needs, including self-reprograming abilities.

Criteria. Does the system automatically provide for dependency tests of needed data by the user? That is, how long will these data be required? Do outputs result in the required coordinated action? Does the cost difference for data exceed the marginal utility of the information to the user? Does the system provide for selective data feedback for operational needs and management decisions?

The operations analysts are responsible for preparing an optimum information system based upon the analyses of the total requirements

Exhibit 6



of the organization. Their output is a network simulation model with computer programs. The model and programs are then tested by management to assure their practicability and management's understanding and acceptance of them.

This effort need not start completely from scratch. Modeling techniques have already been developed, programed and tested by various commercial and governmental organizations. As a result, various state-of-the-art modeling "disciplines" are available for use by the operations analysts. These include such networking techniques for both data and communications as PERT/Time/Cost-Performance methods; such operations research techniques as traffic analysis, queueing theory, linear programing, and the like, decision table techniques; and business simulators and gaming techniques such as the University of California's business game, the General Purpose Simulator, SIMPAC, SIMSCRIPT, and the like. Many of these management science techniques have been described at some length in *Management Services.*

Use of these more or less standard tools will substantially reduce the time required for systems design and thus decrease its cost. With their aid the task becomes an applied science rather than a research and development project. The significant part of the effort will be to determine the fundamental requirements of the particular organization and its management's essential decision making requirements and then to fit these requirements or parameters within the appropriate "disciplines."

Meanwhile the systems analysts have the mission of preparing, as an output, a network reflecting present mechanized data dependencies, data interactions, and data flow and of defining "essential" and "secondary" data. The use of source input/output analysis and data network analysis will greatly aid them in this effort—and will speed their work.

When both groups have completed their assigned tasks, their next step is to unite their efforts to produce the initial data network or preliminary information system. The operations analysts will attempt to adhere to their streamlined model while the systems analysts will attempt to utilize, insofar as is possible, the "best aspects" of the installed applications and subsystems that are currently in operation.

This preliminary design will be reviewed, analyzed, and modified as necessary. Then a second-cut data network, reflecting the anticipated equipment configuration and required equipment capabilities, will be produced in the final design phase. All three phases of the plan for systems design are illustrated in Exhibit 7 on page 300.

A fundamental information system, designed with the aid of these new systems techniques, should go a long way toward solving the problem of the information explosion. Present-day data processing systems are pouring forth more information than anyone can ever hope to assimilate under present circumstances. The ability to generate information has outrun the ability to comprehend it.

Existing information subsystems and application-oriented techniques are not organized so as to permit effective study of the business complex in proper depth. Hence, it is nearly impossible to arrive at solutions revealing the optimum business decisions and the lowest-cost alternatives.

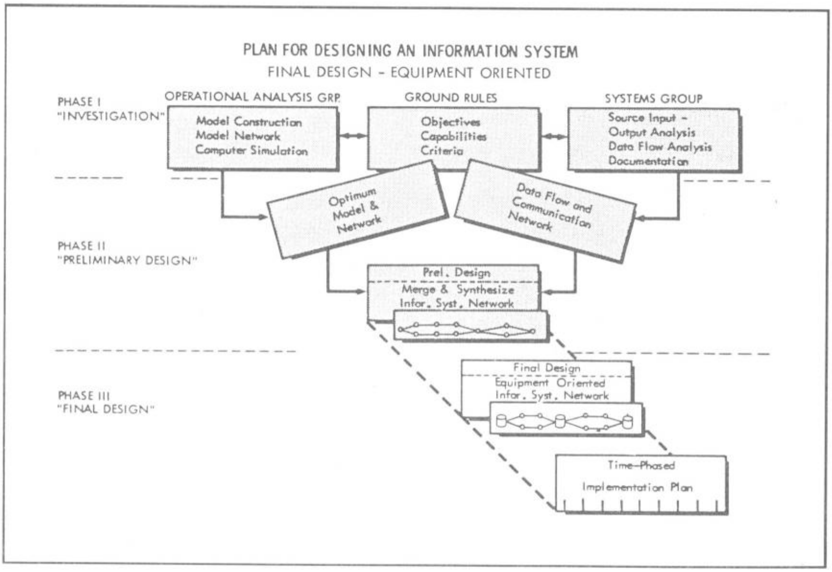
The time and money spent in designing a fundamental information system as outlined here should produce many benefits:

By means of these techniques, the entire fundamental concept of operating the company is studied, perhaps for the first time. The result should be a single-thread flow of information.

Previously unrecognized problem areas and bottlenecks will be uncovered. Data processing activities, manual or mechanized, which are now efficient and should continue despite the adoption of new methods will be isolated. The number of reports and the demand for meaningless data can be reduced, to everyone's relief.

The study should produce a data processing system that justifies its

Exhibit 7



cost since it will be based on solid present and future requirements. One objective of the study must be to find that point of balance at which the payoff expected from the data, documents, reports, and analyses produced is at least equal to—if not greater than—the quantity and cost of data processing to be produced. Since every step taken to improve the accuracy of data transmission increases the cost, the study must include determination of the degree of data accuracy actually required for effective management.

The study—as a catalyst—will help to initiate new systems thinking throughout the organization to match third-generation computer equipment capabilities. It will incorporate or at least foster such scientific techniques as simulation and decision tables, standards engineering, operations analysis, and cost/performance effectiveness analysis.

Management decision making in the new era can be made at a level of information availability never before dreamed of. This means not just more information faster but mathematically pre-analyzed and preselected information from which meaningless data have been culled.

To maintain control and measure the results of business activity is management's responsibility. To do this within a complete information system, the manager must understand the model construction so well that he can assure himself that the solutions coming from these models will reflect policies that will lead to minimum operational costs. Otherwise a manager may be forced into rubber stamping a computer solution. If management is to manage, the decision makers must take the lead in understanding, designing, and approving the model of the fundamental information system.

CHAPTER

10

Toward a Computer Installation

The EDP Feasibility Study

EDP Equipment Selection

Rent or Buy?

THOMAS J. KELLY AND JOHN R. NOLAN, CPA

The EDP Feasibility Study

IT USED TO BE the dream of every management consultant to "install" a computer in a client company, a badge of achievement in an exciting new world.

That was yesterday. Today that dream could be a nightmare, as computer installations of every size and every description mushroom in large and small industries across the country. Some are unnecessary; some are so badly planned that a healthy company can be seriously hurt; some are put in the wrong company, at the wrong time, for the wrong reason.

And, to a very large degree, it's the consultant's responsibility to see that these cases are minimized. This is particularly true when his client is a smaller organization that is flirting with the idea of a computer for the first time. The large company has seen enough of its peers go through computer installation to be aware of some of the pitfalls involved. Moreover, it has the time and the talent on its own staff to take a significant role in the planning that must precede a computer installation. The smaller company, on the other hand, is apt to close its eyes and trust blindly in its outside advisor.

And that's a situation which is likely to be increasingly common in the years ahead as more and more companies take the electronic plunge. Thus, it is only common sense for every management services advisor, whether or not he has ever been a part of a computer operation, to learn as much as he can about what's involved.

The first step in approaching a computer installation is the feasibility study. This is perhaps the most important step of all since all the others stem from it, and serious mistakes or omissions in the feasibility study will be echoed by errors or inefficiencies at each subsequent stage of the installation. There is a point of no return in conversion of a company to computer processing, and once the feasibility study is completed it is being rapidly approached.

There are three questions every consultant should keep in mind before he becomes involved in a feasibility study:

1. Is electronic data processing equipment really necessary to this client at this time? Could increased efficiency and lowered costs achieved through systems improvement outweigh the advantages gained by the installation of a data processor?

2. Assuming EDP machines can be justified, are they desirable because they will bring an almost immediate payoff in making an existing system of operation less expensive (in terms both of space and salaries) or because they will permit greater integration of the entire network of systems by which the company operates? Almost as important, which goal does management want most?

3. Is the company management hoping to justify a computer simply because it wants one, for "prestige" purposes, and with little or no hard, logical justification for one?

No consultant is going to be able to gain the answers to all these questions when he first begins considering the engagement, but, if he keeps them in mind, he can usually learn in his preliminary discussion with management what its major motives are. Then he can frame his program within the context of these motives. For in the last analysis, his plan will only be accepted if it is approved by management. He can persuade, he can point out pitfalls, he may be able to change management's mind, but he has to know what is in that collective mind first.

At this stage of discussions with management, he should also make a careful study of the financial resources of the company. Assuming that a computer would be useful, does the company have the money to make the investment? This is not such an obvious point as it may seem at first. The apparent costs of a computer installation are only a part of the financial outlay that will be needed.

Costs and time for a thorough systems study, costs for programing, and costs of testing the program can be considerably higher than the cost of the basic machines—as many a company has learned to its great sorrow.

With this information garnered from top management, the consultant has the answer to his first question: Could a computer installation offer benefits either in terms of long-run savings achieved through a better and more efficient system or a quick payoff through reducing the number of workers needed in a few major high-volume operations? Alternatively, would it merely satisfy the company's corporate ego—and perhaps even damage the company financially?

Obviously, in either of the last two cases the responsible consultant will try to persuade management to forget its ambitions. If the computer installation would actually damage the company, he can usually, simply by careful and scrupulous marshalling of the figures, talk management into a more realistic attitude. Even if the company will not lose financially, but the computer could do no possible good, it is best to warn management against it. If the company insists, then the consultant would be wise to terminate the engagement. That will forestall recriminations and buck-passing later on.

Except in the case where even a small computer installation is clearly beyond the company's resources, though, most of the instances where management wants a computer solely for prestige reasons will be borderline in nature. Management may not have a very clear or realistic conception of what benefits could be gained from a computer, but a systems study of the company may reveal a variety of areas that could be improved and where savings could be achieved.

However, the management that is eager to buy or rent a computer without being equally ready to spend the time and effort required for a fairly extensive systems study is to be avoided like the plague. Installing a computer without thorough preparation simply invites chaos—chaos which can sometimes take years to straighten out.

So study of the company's present systems is the essential second step in a computer feasibility study.

Here again, the guidance gained from the early conversations with top management can determine the shape of the study. Is the company's goal to gain immediate payoff mainly on a few points of major paperwork volume, or within a single region or division, or does it wish instead to achieve a companywide system where all major paperwork and information flows will eventually lead to or stem from the computer?

The latter requires a comprehensive study of all data processing and record-keeping areas within the company. It is, of course, far more valuable to the company in the long run. Furthermore, it makes much better use of the computer because it utilizes some of the machine's unique abilities beyond its potential for generating an enormous amount of data in an incredibly short time. However, there are instances, especially in companies in which a tremendous amount of clerical effort is expended in one given area, where a computer installation will bring immediate and substantial savings. In such instances it is necessary to go through the process of systems analysis and redesign just in that area and the areas immediately supporting it and depending on it. Utility billing is an example we're all familiar with. Insurance premium notices would be another. For a company that must stock an enormous number of individual machine parts in inventory—a manufacturer of agricultural machinery, for instance—inventory control alone might well justify a computer.

First step in the systems study

Obviously, the systems study will be simpler in the case of a computer application limited to a few areas, although care must be taken to study and possibly redesign the systems in use in areas directly connected with the primary one. But since the same ground rules apply in a systems study for an entire company, let us, for the sake of conciseness, consider that the analyst is faced with the need to make a comprehensive study of all the company's data processing needs as preparation for design of an integrated system.

His first step is to review whatever the company has available in written or graphic form describing its pattern of information flows. These would include organization charts, departmental flow charts when they are available, and tables of equipment and personnel for major areas. He would list major files and their uses and trace major data flow patterns among departments. In the process he would pay particular attention to known problem areas and begin to try to understand *why* they are problem areas. Understaffing? Inadequate equipment? Are they in logical sequence in the overall work flow or do they represent a seemingly illogical spur, a deviation or backtrack in that flow?

He would then list each of the major work areas by importance in terms of the cost of the work performed and the immediate importance to the company of having the work done accurately and swiftly.

This ranking of areas by degree of importance is then matched against computer capabilities to determine just how much improvement in terms of cost or increased efficiency adoption of electronic data processing might bring to the area under consideration. Research and development might be extremely important to a given company—and extremely expensive as well—but it would not be as adaptable to mechanized data processing as payroll or production or billing or inventory control or sales forecasting. (On the other hand, R. and D. might be allotted a certain amount of computer time for its own use in scientific or engineering computations.)

At the same time the overall nature of the company and its primary goals should be taken into consideration. Payroll is a very simple application; sales forecasting a very difficult one. Yet for a manufacturer of women's dresses, sales forecasting would be far more important. The manufacturer must take a chance at the beginning of each season on a number of different models, some of which may sell very well and some of which will never move off the racks. The ability to cut back production fast on the slow-moving items and expand it fast on the popular models on the basis of projections from early sales reports would obviously be a source of greater profitability than cutting the cost of routine payroll processing.

When this comparison has been completed and rough cost, savings, and profit figures worked out, the analyst can determine the primary applications for the computer. Our experience has been that about 10 per cent of the applications usually represent more than 50 per cent of the total data processing work load, and that, if the company has already been using punched cards, almost all the punched card applications will be included.

These preliminary steps concluded, the consultant has a rough picture of what his client's electronic data processing system should, if adopted, try to accomplish. The final decision is not yet made, but the picture at least looks promising enough to warrant further investigation. So far an outline has been created; now the details are to be filled in.

It is at this point that the study team, or committee, is created. So far the analyst has operated more or less alone under a general directive from management. He may have asked occasional questions to clear up particular points that arose in his preliminary survey, but to date it has been largely a project carried through his own work and that of his staff. Now is the time when company personnel must be brought into play to review with the analyst the objectives he has outlined, to fill in details, and to point out gaps in his work.

Prior to the formation of the study team, the analyst should have prepared simplified overall flow charts of the present system and the proposed new system. These should not be prepared in great detail, but they should be precise enough to make clear the major lines of communication between departments and the major work flows within departments.

The study team should be composed of representatives—knowledgeable representatives—from each of the departments that will be directly affected by the installation, plus systems analysts if the company has them on its staff.

In general, department managers are best as representatives, since inevitably some changes in procedures will have to be postulated in the feasiblity study and their acceptance is more likely if the department manager is present in the discussions leading to the proposed change, sees their necessity, and agrees to them right from the start. Furthermore, a recalcitrant department manager finds it much more difficult to defend some pet project, report, work form, or method of his own before a committee of his peers, who clearly see that it contradicts the basic over-all system being developed, than he would in solitary conference with the analyst in his own little domain.

However, the analyst should always remember that the major responsibility for the feasibility study is his, that the departmental representatives are mainly there as a sounding board for his ideas and as a guard against any gaps or errors in his reasoning about the actual needs of their department for information. The department people are line personnel, after all; the study team is just one of their responsibilities. They act as a check on the analyst and as a possible source of suggestions to him; they should never be regarded as the typical vaguely guided and motivated committee in which each member has an equal vote and the majority rules. This group after all is not expected to make any decisions; its only responsibility is to emerge from the study with a recommendation based on facts and logical assumptions.

Generally, it's best to have all the members of the group meet together from the start, but this may be unwieldly in a very large company, or difficult, alternatively, in a company where line management does not have much available time. If it's necessary to stagger committee representation, then it goes without saying that people from departments with related or interdependent functions should be assigned to the committee at the same time. Payroll and personnel should be represented at the same time, for instance, as should inventory and production. Certainly, too, there should always be representatives of the major divisions that will be affected by the conversion—production, sales, finance.

Now the team analyzes the major systems areas of the company. The informal flow charts the analyst has already prepared, with the modifications and corrections stipulated by the departmental people, are further modified on the basis of the total work flow pattern that has emerged from the committee's discussions. Simplifications of procedures are made wherever possible. Time schedules for availability of input information and the requirements for output and periodic or random peak loads are worked out. The volume of transactions to be posted to various documents, records, or reports is analyzed with a careful eye to any possible elimination or consolidation of reports and forms that can be achieved right within the present system.

The last is very important—for two reasons. Unless the present system is tightened, pruned, and improved wherever possible, all kinds of archaic and totally useless forms, work patterns, reports, and records are likely to be carefully preserved in the electronic conversion. (Indeed, in some cases, the computer has made the situation worse by making it so simple to produce extra copies of each.) Then, too, it often will be found that methods improvement, with or without a computer, will bring far greater savings than the computer alone possibly could; what the company really needs is systems improvement, not speedier generation of papers.

There is one other impelling reason for this ruthless elimination of all that is unnecessary from the present system. Clearing the underbrush allows the necessary parts of the system to be seen in much clearer perspective and thus makes it simpler, in terms of the abilities of the electronic data processor, to make really significant systems improvements, to align functions in the most logical order, and not only to transfer clerical processing tasks to the computer but also to eliminate some clerical processing tasks entirely because of the abilities of the computer. Unnecessary paper should be weeded out until only the essential information documents going to the people who really need them remain. Often this process makes it clear that even some of these documents are not really necessary. The computer itself has a memory which can print out information whenever it is called for. Do we really need information reports on inventory, for instance, as long as we can program into the computer instructions to issue orders to restock whenever inventory on a given item goes below a certain level?

So it is vital that the committee carefully analyze the type and complexity of the information contained in various reports and determine the use made of output data.

Naturally, this cannot be done solely on the basis of meetings of the study team. Much of this basic research must be done by the analyst himself through department-by-department interviews, observation, and analysis.

When as much streamlining of the present system as is possible has been accomplished, the members of the study group are ready to determine the requirements for data processing—present and potential. First, they define the correct system requirements, analyzing the data gathered for common data flow, similarities in contents of files, processing procedures, and schedule requirements. Then they can move on to determine the cost advantages or benefits of improved processing that can be gained from mechanization in each area.

Finally, they mesh all their previous findings into the broad concept of a total system for all areas studied, grouping similar activities and eliminating manual communications and filing activities that can be performed by a computer or its peripheral equipment. The cost reduction figures are broken down to distinguish between those which would be achieved by the suggested systems improvements even if the computer project were to be abandoned and those that could only be won through mechanization.

At this point, the possible benefits and savings figures of mechanization have been established, but one essential step still must be taken. What machine, what manufacturer can best meet the needs that have been established in the feasibility study?

There is no one best machine, just as there is no one best manufacturer. Generally, they are all good, but each has peculiar advantages of its own for particular purposes. The larger machines that have modular units can be adapted to a variety of requirements, if the requirements are known. So it is up to the analyst to define the configuration of equipment needed in terms of class, general size, and type of devices (memory, output, etc.) and submit his specifications to the manufacturers who seem most likely to be able to meet his requirements. It is important not to put the cart before the horse. The machine should always be chosen to meet the needs of the system that has been developed, rather than the system's being altered to meet the capabilities of a particular machine or machine complex.

Working with manufacturers

Relations with the manufacturers being invited to submit proposals should not be at arm's length by any means. Rather, the analyst should co-operate with the manufacturers as much as possible in developing their proposals. Often they will be able to suggest improvements in the system that has been worked out or point out alternative methods to those which are incompatible with any computer.

It is also important in the interviews with manufacturers to require that they furnish comprehensive information not only on their machines but also on the back-up services they can provide. How much help are they prepared to give during installation and for how long? How many packaged routines have been prepared for their equipment? How many service people do they have in the locale of the installation? Are there other computers of their manufacture in the area so that processing facilities could be "borrowed" in case of a breakdown?

On the basis of all these factors, the feasibility group prepares its final recommendations—to automate or not to automate, and, if the former, what equipment to use in doing so.

Now the hour of truth has arrived—the presentation of the study group's recommendations to management. A formal report containing the recommendations should be prepared giving the reasons (supported by facts) why the company should decide to approve a computer system. The report should include at a minimum the following information:

1. The general purposes for which the equipment will be used and the principal advantages that will accrue to the company.

2. The basic reasons for recommending the equipment to be used.

3. The effects on the company's organization structure and methods of doing business that may be expected as a result of changeover to electronic data processing.

4. Any special personnel problems that may result from the changeover and, if people will be displaced, the areas in which the loss can be anticipated.

5. A detailed timetable showing how long a time lapse must be expected before the new equipment will be fully functioning, with a reasonably detailed plan showing how the company may carry on its normal business during the period of changeover.

6. Return on investment computations.

In estimating the economic effects of EDP, the analyst should consider and indicate in his report to management these possible advantages:

Inventory reduction (carrying cost, insurance, ad valorem taxes, material handling costs, obsolescence and spoilage, etc.);

Improved production control, resulting in less idle machine time and improved use of manpower;

Better anticipation of customer requirements, lower inventories, fewer stock-outs and lost sales, less overtime for manufacturing rush orders, and shorter production cycle times resulting in improved customer service;

Improved accuracy in order processing and billing;

Better credit control—frequent reports of aged accounts receivable, faster recognition of changing trends in customer preference in styled merchandise, etc.;

Closer control over expenses and investments by comparison with budgets or other forecasts, to be made on a relatively frequent basis;

Analysis of profit and loss by product, salesman, or other profit center.

These figures, of course, cannot be predicted with a high degree of precision, but the fact that they do represent areas where substantial savings might be anticipated should be stressed in the management report.

In addition to the written report, there should be an oral presentation to those members of management who will make the final decision. This report should hit the high spots of the written report, but it should hit them briefly. It is an excellent idea for the consultant to use flip charts or some other visual means to emphasize the points he is making in his presentation, since some people have much better visual than aural comprehension. Also, it is wise to avoid the use of detailed figures in such presentations. The detailed figures are all in the report—or they should be. They will only bore the management group if presented in infinite detail orally. The important questions to emphasize are these:

Will the computer save us money?

Will it improve our operations?

In what areas can we expect the greatest improvement in operations?

How great will our starting costs and conversion costs be?

One final word about the feasibility study, the first step on the road to electronic data processing. Although the consultant should make his verbal presentation brief, dramatic, and succinct, that does not mean that he should not be prepared to answer the most detailed and searching questions from his management audience. So it's up to the consultant to know most of the answers, and to be able to locate rapidly in his copy of the report all of the data that may be requested.

CHARLES KOENIG, JR. AND KURT W. BRUCK

EDP Equipment Selection

THE COMPANY which has completed its EDP feasibility study and has decided that a computer will be a good investment has completed only the first phase of what will be a long, hard process.

A computer, yes, but which computer? There are many manufacturers, each offering a variety of models. And there appear to be an infinite number of factors to be weighed and judged in the decision. A potentially fatal mistake is to start making major adaptations in the system to fit the capacities of some equipment simply because that particular type of hardware has earned the partisanship—or the awe—of some member of management or of the feasibility study group. They may feel safest in choosing a particular type of equipment, even though that equipment by all the standards of the system they and/or the consultants have designed is not as well adapted for the job as some other maker's. It is in the selection of the computer that the company's consultant can make his largest contribution, because he should approach the problem with a completely open mind.

At least at the outset it should be assumed that all equipment offered by the well-known electronics manufacturers is reliable. There are few secrets between manufacturers; the constant traffic in engineers among the companies ensures that. So, any tendency to choose one machine complex over another simply because its manufacturer is favored, for whatever reason, is to be resisted. We belabor this point because only the equipment that most closely fits the requirements of the system that has been worked out is the equipment that should be selected, except in very special cases.

To prepare for such a selection, the first thing the consultant and the study team must do, the first step in equipment selection, is to spell out in detail just what the equipment is expected to do under the proposed new system, the quantity of data it will have to handle, and the interval of time permitted for processing. These are the basics, and the more detailed the information is the more finely tailored the installation can be to the exact needs of the purchaser. Much of this information may not have been gathered during the EDP feasibility study. However, the feasibility study should have resulted in at least the following:

1. What are management's needs and objectives? (a) Reduction in costs? (b) Improved service to the company and customer? (c) Improved management of the business, etc.?

2. The formation of a hard core data processing staff or study team on a full-time basis, guided and supplemented by the experience of the company's consultant;

3. Detailed write-ups of present and proposed systems, complete with flow charts and input and output format requirements;

4. Document counts of all input data, both at normal and peak periods, noting where the input originates and the approximate timing for the receipt of the input data;

5. The number of personnel currently needed to process the operations to be computerized and an estimate of the personnel savings to accrue under a computer system;

6. A listing of all major files currently being maintained and the detailed content of these files;

7. Exceptions to routine processing.

With the above data as a background, the consultant and the study team will have already conducted meetings with all concerned parties throughout the company, considered revising existing operating procedures, and notified management in writing of the results of the feasibility study. Management, on the basis of this written report, has made the decision to proceed with the computer study. We are therefore ready to proceed to the next step. Based on these efforts, the consultant and the study team, in effect, design their ideal machine specifications—then investigate which data processing complexes most nearly match it.

A review of manufacturers' literature readily available to the consultant can quickly and accurately identify those whose equipment seems most nearly compatible with the systems requirements. There is obviously no point in asking a manufacturer specializing in scientific processors with high internal operating speeds, but low input and output speeds, for proposals on a system which calls for the processing of an enormous amount of data through comparatively simple processing steps.

Proposal request

There are two ways to request proposals: (1) Disregard the feasibility study and request that the manufacturers start from scratch. They will send in systems men who will study your present systems and devise new systems tailored to work on that manufacturer's equipment. They will time out the operations and, infrequently, will estimate the potential cost savings to accrue from the installation of their computer. (2) Based upon a feasibility study conducted by the consultant with the aid of the company's personnel, submit to the manufacturers your flow charts outlining the specific areas and systems which the company wishes to computerize, showing the necessary computer runs, the inputs and outputs required, and giving a brief explanation of the processing involved.

In practice we have found the latter approach to be the only logical one. The former approach results in a lengthy systems review conducted on your premises by each computer manufacturer's systems people, which is very time-consuming on the part of key personnel and very often leads to illogical systems approaches because of the manufacturer's inability to learn the company's systems in the necessary detail in the short time allotted. Most serious of all, it results in different approaches by each manufacturer, usually due to specific idiosyncrasies of his equipment, that are virtually impossible to evaluate on a relative basis when the machine proposals are finally received. Thus, we think that precise specifications should be prepared and submitted to representatives of manufacturers of likely suitable equipment. Therefore, in effect, the process of preparing the specifications is an aid to the manufacturers in that it puts in writing precisely what it is that the company wants the equipment to do and the approximate price range or rental fee the company is prepared to pay for getting the job done.

The chosen manufacturers, when they receive the specifications, then go to work themselves detailing just how their equipment could handle the jobs the company wants done. In effect they are complementing the systems design already completed by the consultant and the study team, showing precisely how their equipment could be used within the system, what kind of input would be required, and what kind of output it would produce. The time taken for each operation for a given quantity of data should be part of the proposal.

Analysis of proposals

Upon receipt of the machine proposals, the actual evaluation will begin. A detailed analysis of each manufacturer's proposal must be made by the consultant, preferably in conjunction with the original study group. This evaluation of necessity entails much work and time and should result in the following bench-mark answers for each proposal:

1. Configuration proposed: (a) card-oriented, (b) tape-oriented, (c) random access storage, (d) main-frame storage, (e) input and output devices, (f) special devices.
2. Cost of intended installation: (a) machinery cost, (b) start-up cost.
3. Manufacturer's policy of rental, purchase, and overtime use agreement;
4. Timing of individual operations and total estimate of monthly usage and monthly available hours;
5. Estimates of intended cost savings detailed by department.

By using the above analysis, it should be possible to select those manufacturers who have submitted a "ball park" proposal and thus eliminate those manufacturers' proposals from consideration which do not fall within the range either in costs or timing factors. For a variety of reasons some of the proposals may not adhere to the outline of the system requested. Due to machine limitations or a desire to advance a certain machine feature, the manufacturer may have materially altered the proposed system. This must be resisted at all costs in order that all proposals can be evaluated on an equitable basis.

After this winnowing-out process is completed, there will probably be more than one manufacturer who has offered equipment configurations that look as though they will do the job that has been outlined. Concentrating on the remaining proposals, staff meetings are held with the consultant, the study team, and department heads to analyze the approaches used by the remaining manufacturers. At this time it might be necessary to call in representatives of the machine companies to elaborate on their proposals.

After proper evaluation of each proposal, the consultant and the study team must make a decision. In the present state of the computer market the decision is no longer solely made on price as it was several years ago. After determining that each proposal is economically justifiable, there are other important factors, such as the following, that in a large measure influence the decision:

Modularity: Modularity of the proposed configuration. Can the computer be expanded to meet future needs of the company without the expense of reprograming? It is possible, without a change of basic configuration, to expand many of the already installed systems by adding main frame storage, increasing magnetic tape speeds, increasing the speeds of the input and output devices, and even increasing the speed of the print units. In addition, when systems needs have grown beyond the capacity of an already installed configuration, it is possible, with some manufacturers' equipment, to install the next size range of equipment without having to start from scratch and build a system and rewrite programs. This is so because the programing language of the two configurations is effectively compatible. Conversely, some manufacturers offer equipment that is not compatible and/or expandable and may consequently require lengthy and costly systems and programing efforts each time computer capacities must be expanded. If possible, the latter condition should be avoided and the determination of the modularity or expandability of the equipment examined in view of future needs before placing an order.

Simultaneity: The ability of the computer to handle simultaneous operations. Many of the computers on the market can simultaneously handle two or more operations. In today's technology we are more and more hearing the term "throughput." This is the net time required by the equipment to process all phases of a job. Previously we were concerned primarily with machine speeds, i.e., microseconds of access time, card reading and punching speeds, character rate per second tape speeds, etc. Each processing element was timed separately and all elements added together to arrive at the total processing time. Today with overlap possibilities and multiple channel circuitry we are more concerned with the way complete jobs can be processed simultaneously and the length of time taken for processing all elements per job, instead of the sum of individually timed job segments. The fact still remains that it is virtually impossible, without first programing, to time out jobs with a high degree of accuracy. But equipment that offers processing overlap will obviously process jobs faster and thus require significantly less throughput time, providing the data and logic mix allow us to make use of such capabilities. In addition, demand interrupt features with executive routines available on some computers make it possible to improve throughput time by "multiprocessing" two or more jobs simultaneously, where the relatively slow input-output requirements of several jobs can easily be digested in the main frame of the computer, which might otherwise stand idle awaiting completion of input-output functions of a single job.

Overtime rental: The manufacturers' policy on overtime rental. In the case of more than a one-shift operation, the policy of overtime rental can be a significant factor in the cost of the computer. Some manufacturers offer a base usage of 176 hours per month, some 200 hours per month, and others even more. Some have a very strict accounting of all overtime hours used while others have a more liberal policy toward excess usage beyond a one-shift basis. The rates on a second-shift rental can run as high as 40 per cent of the base rental for the excess time used, but significant differences might be found between manufacturers.

When overtime costs are involved, a cost analysis should be prepared detailing rental costs (including overtime costs) vs. purchase costs (including maintenance and amortization). The analysis should determine if the purchase of the equipment is justified and, if so, a recommendation for purchase should be made to management, after having given full consideration to obsolescence.

Delivery dates: Delivery dates on equipment can be an important factor in placing an order. Although it might appear that the ability to receive equipment on a short-term basis would be advantageous, this is not always the case. It will be to no avail to take early delivery of equipment if the company is not ready for it. Usually it has been estimated that a minimum of one year's effort (multiple man-years) is necessary for systems work and programing before acceptance of the equipment. However, it can also be a disadvantage to be ready to utilize the equipment and have to wait many more months for delivery, installation, and operation.

Although often overlooked, an important function of the consultant is to determine the proper delivery date of the equipment. Too early delivery can result in significant additional cost to the client and possibly chaotic conditions because of crash programing in order to minimize the added cost. Too late delivery can result in the loss of efficiency and morale in the systems and programing group and unnecessary delay in achieving the ultimate goals which were the motivating forces in deciding to make a computer installation in the first place.

Software

The "software" available with every equipment configuration should be checked very carefully. All manufacturers, as a result of their experience in the field, have developed libraries of complete processing routines or subroutines which they will make available to all their customers without charge. If the system that has been developed contains elements covered in these libraries, such as sorts, etc., many of these packaged programs can be used or adapted very easily with a consequent significant saving in programing time and expenses. In addition to softwear packages there are varying degrees of programing complexities between manufacturers. It is estimated that the cost of programing is equivalent to one year's rental of the equipment and in the case of a complex programing system, this cost might be substantially more.

Program language

Since the costs to program the computer are never trivial and the technological advances in the computer industry occur at such a rapid pace, it might be assumed that some time in the future the computer under consideration will be replaced by a new generation specie. A costly reprograming task may be expected at that time unless: (1) the second machine has compatibility with the first, either in engineering design or through packaged conversion programs, or (2) the language for the first computer was COBOL (Common Business Oriented Language) and the general systems approach has not changed in the interim. Thus it becomes a calculated risk to choose between COBOL, a somewhat more difficult form of programing but which offers the promise of reuse in future years, or the manufacturer's own, and generally more efficient, mnemonic coding system which offers less chance of salvage in the future. Generally, we feel, the choice should hinge on the life expectancy of the computer under consideration. If it appears that the first computer will satisfy the company's needs for at least four years of operation, then we would favor ignoring COBOL availability or use, since after such a period the chances of general systems retention become very small.

If the client is a division or subsidiary of a larger company which already has a computer and "cross talk" between computers is desirable, it goes without saying that a check should be made to ensure that the existing computer's input and output formats are compatible with those of the proposed addition.

As stated previously, it is extremely difficult to estimate machine-usage time prior to writing detailed programs. However, logical estimates must be made to guard against buying or renting a computer with greater capacity than is required under present needs. However if the company is expanding so rapidly that obviously the data processing load will be substantially heavier by the time the computer is installed, there would be justification for the installation of a larger computer. But, by the same token, a computer based on modular units should be considered if future expansion is probable. A minimum of upheaval and expense will be encountered under such circumstances. Thus, many manufacturers offer a whole range of configurations composed of individual units—input units, central processors, memory units, output units, which can be assembled in configurations of varying power, speed, and ability. The one error to avoid is being trapped in a system which has been outgrown and cannot be expanded.

Servicing

Even when all of the above factors have been taken into account, the list is not exhausted. Machines break down—and there are endless wholly unanticipated problems when they are first installed. There is usually very little difficulty in getting service from the manufacturing company—any manufacturing company—in a large city, but suppose the installation is in a smaller community some distance from a large metropolitan center. The number of trained and available technical personnel who could be called on in an emergency could be entirely different for two manufacturers whose equipment otherwise is equally desirable. Trained personnel readily available to take care of mechanical troubles or breakdowns are a very important factor in the success of an installation.

Personnel

Equally important is the number of technical people the manufacturer will supply and the length of time for which he will supply them when the installation is first getting under way.

These machine company people are distinct from programers and coders, who should always be employees on the client's staff. As a general rule, we think a company going into electronic data processing for the first time is best advised to make a strenuous effort to build its staff from within the company. If people already on the staff possess the necessary skills and aptitudes to become programers, there are many advantages in sending them to a programing school maintained by the manufacturer. The company has better protection—such personnel have already developed ties and a certain loyalty to the company. Moreover, they are more familiar with its peculiar problems and will have less difficulty in blocking out the detailed machine steps necessary to convert the flow charts of the systems designer into the block diagrams of the programer.

What are the necessary skills and aptitudes to become a programer? How is one to tell whether the necessary abilities are represented in the staff?

Here the manufacturer can be of help, once a definite machine complex has been decided upon. He will give aptitude tests to those of the customer's employees who seem likely prospects, and aid in the final selection. Then the selected employees will be trained in programing techniques at a school maintained by the manufacturer.

One final caution: If programers are to be selected from within the company (or, for that matter, if outside programers are to be hired) they should be sent to school well in advance of machine installation. Programing is a long, involved process and takes a great deal of time. The program for any given data processing job should have a long lead time, or the company is apt to find itself with an expensive machine installation for which it has no programs. This may seem the most obvious of truisms, but it is a point which many companies have overlooked to their grief and expense. As computer prices continue to come down, programing expenses are likely to become proportionately even higher. The systems staff is as important as the programing staff. As mentioned previously the nucleus of the systems staff is usually the original study team. This team should be augmented as necessary, by staff members selected from within the company—preferably with experience in departments whose work will be absorbed by the new computer.

The care and training of programers may seem quite divorced from equipment selection. In one way it is, but chronologically it is so closely allied that selection of future programers and the beginning of their training should occur almost as soon as final equipment choice has been made.

In summary then, it can be stated that the equipment selection should be preceded by a computer feasibility study and the ideal systems design. The final selection of the most suitable equipment will probably require some systems modification. If these steps are not taken in the stated order, the chances of just getting a better mouse trap for the same old system are very high. It must be remembered that new technologies offer entirely different solutions to data processing and management needs. It is the challenge of the consultant and the systems team to discover better systems concepts first, then institute them with the best tools available.

EDWIN D. WOLF, CPA

Rent or Buy?

IN A SERIES of articles on the increasingly important role the computer is playing in our society, *Fortune* estimated that the purchase value of general purpose computers installed in the United States has nearly tripled in the years 1961-1964. In January, 1964, by *Fortune's* calculation, the American economy was utilizing data processing equipment worth approximately 5.3 billion dollars.[1]

Most of this equipment is rented from the manufacturers on a monthly basis in amounts that range from $3,000 to as much as $75,000 per installation. The heavy weighting of a market of this size toward rentals is explained by the combined effects of uncertainty in a new field, a tax structure favoring expense dollars, and superlative marketing techniques on the part of the manufacturers of the equipment. As users become more experienced and knowledgeable in the data processing field, however, the question whether it is more desirable to own than rent data processing equipment arises with increasing frequency.

For many computer users rental payments during the installation and developmental years of their systems have already exceeded the original purchase price of the equipment. The tendency to find more and more applications for an existing computer installation has made the additional rental charges for multiple-shift operation a bigger cost factor than some users anticipated, upsetting their original cost projections.

Furthermore, each of the major factors favoring rental has undergone

[1]*Fortune, June, 1964, p. 115.*

significant alteration in recent years, and many users are reappraising their original positions. Changes in the corporate income tax laws and the attendant investment credits have somewhat decreased the attractiveness of expense dollars as such. The marketing techniques of the manufacturers have changed; most of them have recognized, however reluctantly, that there may be some economic advantage to purchasing equipment instead of renting it.

The most important factor leading to new attitudes, however, has been the dispelling of the early uncertainty as the data processing field has matured. General acceptance of the so-called building block concept of design, which makes it possible to replace individual pieces of equipment as data processing needs change without scrapping the entire system, has eliminated much of the fear of technological obsolescence that was such a powerful deterrent to purchase in the early days of EDP. So have such developments as the growth of the used computer market, with its effect on trade-in values, and the opportunity to hedge the risk by renting with option to buy.

Thus, the increased sophistication of users has tended to remove one of the primary arguments for renting. Many users, adopting an initial philosophy of proceeding with "all deliberate care," acquired—usually by rental—only that equipment needed to gain experience with the basic concepts of data processing so that they could determine how such equipment might best serve the needs of their organizations. Now that this experience has been gained, management is in a better position to prescribe the type and range of equipment needed for the next few years of company growth. With the necessary foundation established, management now can properly ask: Why not buy rather than rent?

The world's largest single data processing customer has also been asking this question. In March, 1963, the Comptroller General of the United States reported to Congress that more than 86 per cent of Federal data processing installations were utilizing rented equipment. If about 500 of the more than 1,000 installations were to purchase their equipment, the Comptroller General estimated, the American taxpayer could save $148,000,000 during the first five years and about $100,000,000 per year thereafter.[2] No company's cost factors approach this magnitude, of course, but for every computer user the problem deserves some attention and evaluation.

The emphasis in this article is on the practical aspects of the rent or buy decision. The problem discussed is not how to justify the equipment

[2]*Study of Financial Advantages of Purchasing Over Leasing of Electronic Data Processing Equipment in the Federal Government—Comptroller General of the United States, March, 1963.*

in terms of clerical savings but rather how to decide whether to rent or purchase a piece of equipment whose installation has already been decided upon.

A careful analysis by a company's data processing staff should provide the basis for the choice. These are the persons with the knowledge and experience necessary to judge the effect of a particular piece of equipment on the company's data processing activities. They are better equipped, too, to gauge the effect on the usefulness of the equipment of changes in the data processing activity.

Without a realistic analysis by people who understand the company's data processing needs, consideration of financial theories will be nothing more than academic exercises. Much time will be spent in compilation and discussion of irrelevant data, and the result may well be erroneous.

Sound analysis involves the intelligent use of basic information about the company's needs and how the equipment can meet those needs. Some crystal ball gazing is required in trying to foresee what the company's data processing activities will be in coming years.

For a rent versus buy comparison for any one piece of equipment, these questions must be considered:

1. What is the annual rental? Are there any taxes?

2. What is the purchase price? What taxes must be paid? What will be the insurance costs?

3. What is the expected system life of the machine?

4. What will the annual maintenance cost be?

5. What will the salvage value of the machine be when the company no longer has use for it?

6. What will be the rate of interest for money the company borrows? What rate of interest should be attributed to money it has?

Rental and purchase

Determination of the rental and purchase cost is a fairly straightforward task. It should be pointed out that in analyzing the costs of a machine already installed, purchase price is the price to be paid now, not the original purchase price. (An analysis of this type is just as valid for installed equipment as it is for that proposed.) The rental will include the rate charged for use of the machine to whatever extent planned, if such use extends beyond a normal shift.

Unlike punched card equipment, computers and their attached data-handling equipment are not subject to the Federal excise tax. There may, however, be local sales taxes to pay. Insurance on the equipment must be paid by the owner and hence is an added cost associated with purchase.

The most important single item in the analysis is the system life of the equipment. This evaluation must be made by data processing personnel. Estimating the equipment's system life is extremely difficult. It involves many of the same problems encountered in determining the original systems approaches for the company. The company's EDP personnel must be realistic and practical about the functional value to their activity of a given unit of equipment. They must ask realistically and practically how long this unit of equipment will serve the company's needs.

Obsolescence

Here we meet one of the most abused terms used in connection with rental versus purchase decisions: obsolescence. Too often the term is used as a substitute for a serious, objective analysis of a situation.

The members of the company's data processing staff keep abreast of techniques and equipment as developed. This puts them in a better evaluative position than the general management group. Thus, with their advance "inside" knowledge, they may be prone to characterize today's equipment as old-fashioned. Theoretically, they are right. However, we are not asking whether the equipment is technologically obsolescent but rather whether it is functionally obsolescent:

Can this equipment do this job effectively within the framework of the company's operations? If so, how long is its functional life in the operation?

Any of us can speculate on how long any one piece of equipment is going to be the ideal tool for its job. As computers became more economical and more sophisticated, punched card equipment, instead of being the prime data processing tool, was relegated to a peripheral or auxiliary function. Just as transistorized computers have replaced vacuum tube computers, character recognition may eventually replace keypunching as the major means of input.

However, the real test of functional obsolescence lies in a particular company's own situation. Where does this company stand in its development of data processing? What will it be doing three years from now? In five or ten years? What will the applications be? What will the volumes be? What pieces of equipment on hand today will still be required to carry a major part of the data-handling load tomorrow?

This question of system life is the primary consideration in any purchase evaluation. A carefully thought out answer can mean real dollar savings for the organization.

The reader should note that these comments refer to a unit or a piece of equipment rather than to the assemblage or collection of units that make an installation. The system life of an entire configuration of equipment cannot be appraised intelligently. Each type of equipment has a specific job, a job that can continue, disappear, or grow as the company's activities and techniques change. For example, when punched card equipment is replaced as the prime information processor by a computer, that does not necessarily eliminate punched card handling altogether. So each piece of equipment and its relation to the whole data processing picture should be considered individually.

Forecasting the future

How can we appraise the company's data processing future? We must know today's system and the areas it encompasses, the peak load volumes, and the schedules of input and output that largely dictate the present installation. Then we must forecast what the future holds.

Every organization must plan. Goals are set for next year's sales, production, and purchases. Trends and relationships are analyzed; someone is charting the company's course. As in any budgeting and planning activity, an intelligent estimate is far superior to a wild guess.

So, too, with the company's data processing. What areas are scheduled for new or expanded mechanization? Will the use of cards as input increase or decrease? Will the present volume hold firm? Is the printing load likely to go up or down? Will reports be simplified in format? Will increased use of management by exception reduce some of the current detail printing load? What changes will take place in the data processing concept itself?

Essentially, what we must do is construct a model of the company's data processing future. On top of today's activities we must place tomorrow's data-handling requirements—visualizing the processing structure. The projections of company sales, payroll, purchasing, and such other basic activities can be converted to the volume of data to be handled, the schedules to be met, and finally into the approximate magnitude of the equipment that will be required for tomorrow's data processing function.

As a by-product of this estimating, we get one of the side benefits derived from doing normal budgeting: We get our people to think more intensively about their jobs and thus better equip them to do their jobs more effectively.

One of the hazards, of course, is the natural tendency with which data processing people seem particularly well endowed—to become too grandiose or too sophisticated in plans for the future. It is much like the problem of some accountants. Every once in a while we have to remind ourselves that the company is not in existence to provide figures for the accounting department but rather the other way around. Similarly, we have to forestall the data processing people's tendency to try to turn the entire organization into one large computer center. However, with close review and the leavening influence of practical management, we can come fairly close to reasonable projections.

When we have built tomorrow's model, we must then look at those areas of the processing structure that are most susceptible to change through technological improvements. Nobody can deny that the data processing industry is making—and will continue to make—great advances in the state of the art. The questions to be considered are these: Where? How much? How fast? And—the most important question—which areas of the company's processing are likely to be affected?

We will probably find that many areas may very well not be subject to any wholesale, radical changes during our projection period. For example, if we have a decentralized data origination system, the current methods, even when considering the projected volumes, may be the most suitable for that type of operation. Similarly, the view we take of a central processor is conditioned by the degree to which its command structure, memory capacity, and processing speeds will meet our needs of tomorrow. So we must ask ourselves how long the existing equipment in these areas will continue to fulfill their functions. The answers are often surprising.

Think of the time requirements of surveys, cost estimating, planning, and installing in gauging how soon existing equipment will be replaced. Those who have lived through feasibility studies, equipment installations, and system shakedowns will probably agree that major changes do not come about rapidly nor are they undertaken lightly. When we look four or five years into the future, we are not looking very far. No matter what the main data processing configuration will look like eventually, chances are that some of the present equipment will still be in use.

It is not necessary that all these projections be pinpointed specifically before analysis can move ahead. This forecasting is designed simply to provide a realistic idea of the system life of the individual components of an existing installation. The items that have been reviewed are major considerations in determining the system life of each piece of equipment. Once that system life has been determined, each unit should be analyzed on the assumption that it will be disposed of at the end of that life. Sometimes the productive life as estimated by the manufacturer is used as the system life. Ordinarily, however, the manufacturer's figure can be ignored, except that it should be as long as or longer than the estimate of the system life finally used.

Most rental plans provide for manufacturer maintenance of the equipment. The cost of the same degree of preventive and breakdown maintenance must be paid by the user if he owns the equipment.

Maintenance contracts usually provide for preventive and repair maintenance on a standard shift, including the cost of replaced parts. If equipment use is contemplated beyond a standard shift, the maintenance costs will increase, generally on a stepped basis. Maintenance contracts also can be predicated on a time and materials basis.

Cost schedules for both types of service, varying with the type and age of the equipment, are available from manufacturers. For the purposes of comparative cost analysis, the frequency and seriousness of equipment breakdowns must also be estimated.

The salvage value of the equipment at the end of its system life represents a plus factor that is often ignored in cost comparisons. If the system life of a unit is shorter than its productive life, the user will have an asset of some real worth. This is becoming increasingly significant because of the small but constantly growing market for used equipment.

Manufacturers publish lists of trade-in values by type and age of equipment. Relating these values to the expected age of the equipment at the end of its system life will provide a reasonable indication of the approximate value of the equipment at that time.

Conservatively, the salvage value of a unit should be treated as trade-in value rather than potential cash realization. Many manufacturers restrict the proportion of new equipment cost that can be absorbed by the trade-in value of the older equipment.

The rate of interest the company pays for borrowed money or the rate it expects to earn on an investment is used to place the various costs on comparative bases. The appropriate rate may vary depending on the organization and the type of activity being considered.

Leasing as a compromise

In any equipment acquisition, the relative merits of entering into a lease agreement with a third party should probably be given some consideration. This method of acquiring data processing equipment has been receiving increasing attention recently, particularly with the entry of commercial banks into the field.

The variety of lease arrangements and the complexity of their details can, of course, justify a separate article altogether. However, the nub of the argument for leasing appears to be two-fold:

1. Costs of equipment under a true third party lease can be wholly expensed by the equipment user.

2. Out-of-pocket costs, in comparison to rental from the manufacturers, may be somewhat less during the initial term of the lease and significantly less for subsequent lease periods.

The cost impact of leasing arrangements seems to have undergone material alteration recently. Originally, while some savings over rental charges could be effected for equipment used on a standard shift only, the major cost advantage accrued to those installations requiring multiple-shift utilization. Manufacturers' rental charges for extra-shift use, although not directly proportional to their base charges, represented a major cost item to the user. With a leasing arrangement, monthly charges were constant (except for incremental maintenance costs), and leasing thus provided material savings over rental for multiple-shift use.

Most of the major manufacturers have now revised their rental arrangements significantly. Greater recognition is given to the actual productive use of individual units, and charges are not made for such nonproductive items as set-up and standby time. This, naturally, materially reduces the margin of savings to be realized through leasing.

The decision to lease rather than rent should be made on the basis of the same cost factors considered in deciding to buy rather than rent. Whether the user should lease rather than purchase is fundamentally a question of availability of capital funds for equipment acquisition either within the company or from alternative sources.

The mechanics of a comparative cost analysis are fairly straightforward once the problems of applying the interest rate and valuing the money have been conquered.

Two aspects of money value are considered. To determine the net purchase price to be amortized over the system life we deduct the present value of the salvage we expect to realize at the time of disposal. Since the dollars we expect to receive some years from now are not the same as today's dollars, we place this amount on a current basis by using standard reference tables to find the present value of 1 at the prescribed interest rate for the period of estimated system life. We then treat the net purchase price as an amount to be paid off annually over the period of the system life at the desired interest rate.

Exhibit 1 on pages 332-333 illustrates one way of developing this

Exhibit 1

COMPARATIVE COSTS ANALYSIS

Equipment: Medium-scale computer
Premises: 4-year system life — all units
6% cost of money

	(1)	(2)	(3)		(4)	
	Rental		Purchase			
Equipment Units	Monthly	Annually	Price	%	Salvage Value	Factor
		12 x (1)			% x (3)	
1 Processor	$ 3,280	39,360	156,650	12	18,798	.792
1 Card Read-Punch	550	6,600	30,000	12	3,600	.792
1 Printer	775	9,300	34,000	12	4,080	.792
5 Tape Drives	3,500	42,000	180,000	12	21,600	.792
Total Installation	$ 8,105	97,260	400,650		48,078	

analysis. The example is an analysis of the units making up a small to-medium-scale computer installation. Our data processing people have decided that the entire configuration will be replaced in four years. We value our money at 6 per cent. You will note that each unit is scheduled individually.

Column 1 shows the monthly rental for the unit, which we multiply by 12 to get the annual rental as shown in Column 2. Our gross purchase price is in Column 3. If we are in a sales tax area, that amount includes taxes. It also includes the total of insurance costs over the system life of the machine.

Column 4 shows the salvage value based on the manufacturer's estimate that 12 per cent of the original value will be allowed at the end of four years. We then determine the presesnt value of those four-years-hence dollars by multiplying by the present value of 1 factor of .792. Our product is shown in Column 5. Subtracting the present value of the salvage from our purchase price gives us the net purchase price shown in Column 6.

(5)	(6)		(7)	(8)	(9)	(10)	
Elements				**Annual Mainte-nance per Shedule A**	**Total Annual Cost of Pur-chasing**	**Annual Differential Favoring—**	
Present Value of Salvage	**Net Purchase Price**		**Annual Purchase Cost**			**Rent**	**Purchase**
Factor x (4)	(3)—(5)	**Factor**	(6) ÷ Factor		(7) + (8)	(9):(2)	
14,888	141,762	3.465	40,913	1,080	41,993	2,633	—
2,851	27,149	3.465	7,835	589	8,424	1,824	—
3,231	30,769	3.465	8,880	2,127	11,007	1,707	—
17,107	162,893	3.465	47,011	7,035	54,046	12,046	—
38,077	362,573		104,639	10,831	115,470	18,210	—

We now want to determine the annual payment (at 6 per cent interest per year) that would have to be made in each of the four years to equal this net purchase price. The present value of an ordinary annuity of one for four years at 6 per cent is 3.465. By dividing the net purchase price by that factor, we find the annual purchase cost shown in Column 7. This is the amount we would have to pay out each year to accumulate our purchase cost including interest.

The maintenance cost for each unit of equipment is developed in Exhibit 2 on page 334. You will note that the monthly maintenance rates vary depending upon the age as well as the type of equipment. Here we have used a weighted average for the annual maintenance cost to give effect to the higher costs at the end of the system life. This average annual maintenance is shown in Column 8 of Exhibit 1.

The addition of the annual purchase cost to the annual maintenance cost gives us the total annual cost of purchasing as shown in Column 9 of Exhibit 1. This is what we compare to the annual rental costs in Column 2 to determine the differential favoring one approach over the other. As can be seen in Column 10, rental represents an appreciable annual saving over purchase when a four-year system life is used for all units.

Management and data processing personnel now must appraise their estimates. In light of data processing plans, the company's growth, and the state of the data processing art, is four years of realistic appraisal of the system life for all units? The answer, of course, is highly subjective. You can get as many answers as you have people—and many more if they can put qualifiers or "ifs" on each of their answers: "If we double volume, we'll need faster tapes to maintain present schedules." "If we go into scientific calculations, we'll need more memory

Exhibit 2

SCHEDULE A
MAINTENANCE COSTS OF UNITS WITH 4-YEAR SYSTEM LIFE

1. Processor		
36 months @ $88.25/mo.	$ 3,177	
12 months @ $95.50/mo.	1,146	
Total maintenance	$ 4,323	
Average annual maintenance (Total ÷ 4)		$1,080
2. Card-Read Punch		
36 months @ $45.00/mo.	$ 1,620	
12 months @ $61.25/mo.	735	
Total maintenance	$ 2,355	
Average annual maintenance (Total ÷ 4)		$ 589
3. Printer		
36 months @ $172.00/mo.	$ 6,192	
12 months @ $193.00/mo.	2,316	
Total maintenance	$ 8,508	
Average annual maintenance (Total ÷ 4)		$2,127
4. Tape Drives		
36 months @ $580.00/mo.	$20,880	
12 months @ $605.00/mo.	7,260	
Total maintenance	$28,140	
Average annual maintenance (Total ÷ 4)		$7,035

in the processor." Somebody in management must filter these "ifs" and establish some ground rules to enable the group to arrive at a workable decision.

Exhibit 3 (on pages 336-337) illustrates the effect of adopting varying system lives. It was assumed that the tape units and the card unit would be replaced at the end of four years. However, the investment in programing and debugging the processor and the 8,000 positions of memory now available make eight years seem a more realistic system life for the processor. Similarly, the printer should serve well for eight years. (It should be remembered that these decisions are made within the framework of an existing situation and can be subject to endless debate.)

Cost values based upon an eight-year system life for the processor and the printer are now computed. The rental and gross purchase amounts are, of course, the same at the end of eight years although the manufacturer says that there will be no trade-in or salvage value. Therefore, the net price is the same as the gross price.

The annual purchase cost changes significantly with the doubling of the system life for these units. Note, however, that the additional interest costs do not allow for a proportional reduction. Doubling the life does not halve the cost. In Exhibit 4 (page 336) the weighted average annual maintenance costs have been recomputed. Again, the longer life raises the annual costs because of the higher maintenance rates for the older equipment. The new comparison of annual rentals with the annual costs of purchasing these units is now significantly different from the first example.

Management might well ask, "How can we afford not to buy?" However, the realism of the estimate of the length of time in which each piece of equipment can be put to use in the company must be questioned continually.

As an alternative technique, the annual costs for varying system lives of each unit could be plotted on a breakeven chart and the point of purchase advantage clearly indicated. The danger of this course, however, is that it may create a tendency to select a system life from a financial viewpoint rather than a functional viewpoint. Savings through purchase can be shown easily. But unless the equipment continues to be useful, management is only deluding itself.

The comparison outlined in this article will provide a starting point from which financial people can begin to assess the tax effects of the decision and its effect on the cash-flow position. They can build on a firm foundation of practical value to the company's data processing operations.

Exhibit 3

COMPARATIVE COSTS ANALYSIS

Equipment: Medium-scale computer
Premises: 4-year system life for Card and Tape units
8-year system life for Processor and Printer units
6% cost of money

	(1)	(2)	(3)		(4)	
	Rental		Purchase			
Equipment Units	**Monthly**	**Annually**	**Price**		**Salvage Value**	
		12 x (1)		%	% x (3)	**Factor**
1 Processor	$ 3,280	39,360	156,650	0	—	—
1 Card Read-Punch	550	6,600	30,000	12	3,600	.792
1 Printer	775	9,300	34,000	0	—	—
5 Tape Drives	3,500	42,000	180,000	12	21,600	.792
Total Installation	$ 8,105	97,260	400,650		25,200	

Exhibit 4

SCHEDULE B

MAINTENANCE COSTS OF UNITS WITH 8-YEAR SYSTEM LIFE

1. Processor

36 months @ $88.25/mo.	$ 3,177	
36 months @ $95.50/mo.	3,438	
24 months @ $108.00/mo.	2,592	
Total maintenance costs	$ 9,207	
Average annual maintenance (Total ÷ 8)		$1,151

2. Printer

36 months @ $172.00/mo.	$ 6,192	
36 months @ $193.00/mo.	6,948	
24 months @ $217.00/mo.	5,208	
Total maintenance costs	$18,348	
Average annual maintenance (Total ÷ 8)		$2,294

(5)	(6)		(7)	(8)	(9)	(10)	
Elements				**Annual Maintenance (per Schedule A or B as Indicated)**	**Total Annual Cost of Purchasing**	**Annual Differential Favoring—**	
Present Value of Salvage	**Net Purchase Price**		**Annual Purchase Cost**			**Rent**	**Purchase**
Factor x (4)	(3)—(5)	**Factor**	(6) ÷ Factor		(7) + (8)	(9):(2)	
—	156,650	6.21	25,225	B 1,151	26,376	—	12,984
2,851	27,149	3.465	7,835	A 589	8,424	1,824	—
—	34,000	6.21	5,475	B 2,294	7,769	—	1,531
17,107	162,893	3.465	47,011	A 7,035	54,046	12,046	—
19,958	380,692		85,546	11,069	96,615	13,870	14,515

Glossary*

Assembly printout. A listing of a program which shows (a) the program steps written by the programer in the easier-to-use assembly language and (b) the machine code version of the program into which the assembly language has been translated by the computer.

Auditing "around." The process of auditing where an EDP system is in use that does not make use of the computer itself. Transactions are traced from source to final reports, or from final reports to source, by using the computer printouts as if they were records maintained by a manual system.

Auditing "through." The process of auditing where an EDP system is in use by making use of the computer itself; the adequacy of computer programs is checked by means of test decks; also, programs developed under the supervision of the auditor can be used for selecting records for detailed analysis, while other programs can perform some of the analysis itself.

Authorization test. A form of programed validation check. A transaction is checked against one or more tables of valid numbers to determine, say, whether the department specified in the transaction is authorized to initiate that kind of transaction.

Balance printout. A periodically prepared report showing the opening balance for each account in a file, a summary of all activity for the account during the period by type, and a closing balance for the account.

Batch. A quantity of transactions which have been saved up to be handled as one lot.

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* *Prepared by Lybrand, Ross Bros. & Montgomery.*

Batch controls. Techniques for insuring the completeness and the accuracy of the movement of batches of transactions; includes items counts, control totals, and hash totals.

Changes to programs. See *program changes.*

Character mode test. A form of programed validation check. It tests to see that all characters within a field are of the prescribed mode—that is, numeric, alphabetic, alphanumeric.

Cobol. The "Common Business Oriented Language" for programing business type problems. One of the languages whereby programs are written in a form resembling English, but with a rather rigid syntax and a vocabulary restricted and completely consistent in usage, and are translated by a computer program (a compiler) into the machine code required by the computer.

Code, machine. See *Machine Code.*

Coding sheet. The sheet on which the programer writes the detailed machine instructions prior to conversion to machine language and entry into the computer; a part of program documentation.

Compare and branch. See *Conditional Transfer.*

Compiler. A program that prepares a machine-language program from a computer program written in another language, such as COBOL.

Compiler printout. A listing of a program which shows (a) the program steps written by the programer in the easier-to-use compiler language (such as COBOL) and (b) the machine code into which the compiler language has been translated by the computer.

Completeness test. A form of programed validation check that tests to see that all necessary fields of information are present in a transaction.

Conditional transfer. A computer instruction which (a) analyzes the results of a previous comparison of two numbers and (b) causes the computer either to continue with the next instruction in the original sequence or (c) transfer control (branch) to another stated instruction, depending upon the results of the previous comparison. An example: continue with the next instruction in sequence if the two numbers are equal; branch to another instruction if they are unequal. This type of instruction gives the computer much of its power.

Console operator. See *Operator, console.*

Console typewriter. A device provided with some computers by which the computer operator may enter instructions and data into the computer and by which the computer may type out pre-programed messages.

Control group. A group of clerks to which all data flowing to the computer is channeled and from which all computer reports are distributed. The main functions of the group are to detect and correct data movement errors and to correct errors detected by the programed validation checks in the computer.

Control total. A total of one information field for all of the records in a batch; an example would be the total dollars represented in a batch of department-store sales checks.

Data conversion controls. Controls applied to the process of converting human language to machine language; the most pressing need for control occurs when the conversion is performed manually, e.g., by key punching data into punch cards.

Data movement controls. Controls applied in moving data from its source to its ultimate disposition; these include the use of batch totals and control groups.

Data transmission. See *Wire transmission.*

Debugging. Locating and correcting errors in a computer program.

Dummy master record. A record inserted into a file for testing or auditing purposes; it would be handled like a regular record but would contain fictitious data.

Dummy transaction. A transaction injected into a data processing system for testing or auditing purposes; generally, dummy transactions would be posted to dummy master records, so as not to contaminate the regular records in the file.

Error listing. A list of all of the types of errors which a program has been designed to detect, the probable cause of such errors, and the most likely necessary corrective action. This listing is prepared by the programer when he writes the program.

Error switches, internal. Internal electronic "switches" that are turned on automatically by the computer when certain types of errors are detected such as tape read and tape write errors. Following the operations in which such errors can occur, it is usually required that the program test to see if a switch is "on;" if so, the program must branch to the appropriate error handling procedure.

Exception reports. Reports that do not list all of the records in a file, or all of the transactions in a batch, but only those that fall outside of a normal or expected range.

Father tape. See *Grandfather-Father-Son.*

Field validity tests. A form of programed validation check that tests the value of a field against fixed or reasonable limits; for example, the day of the month should never exceed 31.

File. An organized collection of related records, such as a customer file, a vendor file, or an employee file.

File protection. See *Record security.*

Flow chart. See *Machine flow chart.*

Grandfather-father-son. The principle of maintaining three generations of magnetic tape files. In an updating process, the input file to a computer run is called the "father" file, and the updated output file is called the "son" file. Similarly, the file that was used as input in the updating once removed is called the "grandfather" file. If recording flaws are detected when reading the "father" file, the "father" file can be reconstructed by processing the "grandfather" file again.

Hash total. A total of one or more information fields for all of the records in a batch used as a control mechanism. The total need have no intrinsic significance—e.g. the sum of employee numbers or social security numbers—since it merely checks for deviations from one operation to the next. Deviations in hash totals between one operation and the next might indicate loss of an item of data, perhaps loss of a punch card.

Item count. The count of the number of items or transactions in a batch; if there can be a variable number of documents per transaction, the count must specify whether it applies to the transactions or to the documents.

Keypunch (verb). The act of converting human language to machine language by means of a manual operation; most generally, the machine language is recorded in a punched card or punched paper tape.

Label, internal. A magnetic record at the beginning and/or end of a magnetic tape file identifying the reel. With such identification, a computer program can determine whether the correct file tape has been mounted on the tape unit.

Ledger-type printout. A written record that shows both a line-by-line listing of transactions affecting an account and the resultant account balance.

Library, program and files. A repository for storing magnetic tapes, punched cards, or punched paper tape containing the computer programs for the installation, as well as the master files and transaction files.

Log. A listing of all transactions of a specific type; logs for EDP include (a) errors detected and printed out by the computer; (b) everything pertinent to a machine run, such as identification of the run, set-up actions taken, input-output files used, and actions taken by the operator each time the machine halted; (c) an accounting of all machine time, including productive time, idle time, rerun time, etc.; and (d) a listing of all tapes withdrawn from the library and returned to the library, showing date and time, to whom issued, and computer runs for which issued.

Machine code. The computer program in the form that it is used by the machine.

Machine flow chart. A graphic representation of the flow of information between computer runs, for a system or application. The level of detail is such that the computer runs are identified by name or number, as opposed to a detailed description of the operations the runs perform. See *Program Flow Chart,* detailed.

Machine language records. File records, transaction records, and report records in a form that can be read by the machine; an example would be transaction records stored on magnetic tape.

Machine process run charts. See *Machine flow chart.*

Magnetic tape system. An EDP system which uses magnetic tapes as the primary form of file and transaction record storage.

Message. A group of characters transmitted as a unit; transactions are sometimes called "input messages" and report records are sometimes called "output messages."

Narrative. The written description of the flow of information in the system.

On line-real time system. An EDP system in which transactions are processed as soon as they occur, with any necessary responses made immediately. In addition to the computer, such systems generally make use of random access memories, wire transmission, and transaction recorders.

Operator, computer. The person who manipulates the computer controls, places information media into the input devices, removes the output and performs other related functions.

Parity check. A built-in internal computer check against malfunction in the machine's movement of data. At the point of input the computer automatically puts every character of input on a "par" by making the binary digit totals for every character universally odd or even depending on computer design. This parity is established by the addition of a digit (check bit) to those totals that do not follow the odd or even design. Departures from this parity in the course of later processing will signal an error.

Policy test. A form of programed validation check that tests policy relationships between fields within a record; an example would be checking the amount of a new mortgage loan against the valuation of the property.

Program. The complete sequence of machine instructions and routines necessary to solve a problem or process data.

Program change. Any change, from a minor change of one machine instruction up to a major modification of a large segment of a program.

Program change control. A standardized procedure for reviewing and approving all proposed program changes and for recording the status of the program both before and after the change, the date of the change and the date it became effective in the processing, the name of the person making the change, and the procedure for physically changing the program library tape.

Program change sheet. A listing containing all changes made to a program, the date each change became effective, the person making the change, and a cross reference to the details of the change.

Program flow chart, detailed. A graphic representation of the computer program, using a standard set of block symbols to represent the computer operations. Concise symbolic notation—based on the operations and characteristics of a particular type of machine—is used to represent the information and describe the input, output, arithmetic, and logical operations involved. See *System Flow Charts.*

Program library. See *Library.*

Program loading routine. A routine which, once it is itself in the computer's memory, is able to bring the remainder of the program into the computer's memory from magnetic tape or punched cards.

Program logic chart. A graphic representation of the major steps in a computer program, showing how the problem is attacked logically. Notation is in English and is not related to the operations and characteristics of any one type of machine.

Programer. A person who prepares the problem-solving procedures and flow charts for solving a problem on a computer, and who may also write and debug the routines. The definition of the job to be done is either provided to the programer by a systems analyst or the programer does systems analysis work as a part of his duties.

Quiet errors. Certain errors that might go unobserved or be quietly accommodated under the more flexible and tolerant manual systems, but which are immediately brought to light under the rigid discipline of computer programs, which require an internal consistency manual systems do not.

Random access memory. A storage technique in which the time required to obtain information is (relatively) independent of the location of the information most recently obtained. This technique of record retrieval is contrasted to sequential memories (such as magnetic tape) where records are obtained in a sequential fashion, not in a random fashion.

Read-after-write check. A built-in equipment control feature that reads information back from the storage medium, after it has just been recorded, and checks to see that the recording agrees with the original information.

Record. A group of related facts or fields of information treated as a unit; a record usually applies to an event (a transaction) or to a thing (such as a specific customer or a specific product).

Record layout. A listing of all of the fields of information in a record and the manner in which they are arranged in the record.

Record security. The ability to reconstruct records in case they are found to be damaged or in error; the "grandfather-father-son" principle provides a means to reconstruct records in magnetic tape systems. For random access memories, record security requires periodic copying of the file onto magnetic tape, punched cards, or other random access discs to provide the ability to reconstruct the records should the need arise.

Redundancy. The fraction of the gross information content of a message that can be eliminated without the loss of essential information. In EDP systems, planned redundancy is used to check accuracy of information transmission.

Rejected transactions. Transactions or batches of transactions that have failed the various internal control tests.

Run. (production run) A self-contained computer operation—e.g. preparation of a payroll—which requires no (or very little) intervention by the computer operator into the operation of the computer itself. Common in business applications, where operations are more routine, less so in scientific applications.

Security. See *Record security.*

Self-checking number. A number the last digit of which is a "suffix digit," not a part of the quantity represented by the preceding digits but having a consistent relation to the preceding digits or quantity (usually a sum). Deviations introduced into the previous digits, in the course of transmission or conversion of data, will alter the relationship and signal an error.

Software. The totality of programs and routines used to extend the capabilities of the computer—compilers, assemblers, etc. Frequently these programs and routines are provided by the computer manufacturer.

"Son" tape. See *Grandfather-Father-Son.*

Suspense file, rejected transactions. A file of rejected transactions for which corrective entries to the program have not been received. This file provides a control mechanism for the entry of corrections.

Symbolic programing language. The use of mnemonic symbols to represent computer operation codes, memory addresses, and data, so as to make programing easier and to reduce errors.

System flow chart. See *Machine flow chart.*

Systems analyst. The person who performs the analysis of a business activity to determine precisely what must be accomplished, and who lays out the overall design of the new system. If he does not also do the programing, he must communicate the specific requirements for each computer program to the programer(s).

Tape label. See *Label, internal.*

Test deck. A set of data developed specifically to test the adequacy of a computer program or group of programs, either for debugging the program or for testing the internal control features incorporated in the program.

Three generation principle. See *Grandfather-father-son.*

Transaction. A record of occurrence of a new event; an input message for a data processing system.

Transaction recorder. A device for recording a transaction in machine language at, or close to, the point at which the transaction takes place. A printed copy of the message may or may not be prepared; the machine language message may be stored in the transaction recorder (for example, on punched paper tape) or it may be transmitted by wire to a central processing site.

Transaction reference number. A number included as part of a transaction record to provide a reference for locating the original source document of the transaction; such a number might consist of a date and a batch number.

"Turn around" document. A document prepared by an EDP system so that it may re-enter the system as input. Bills prepared on punched cards are an example.

Typewriter. See *Console typewriter.*

Update. To bring a master data file up to date, by posting recent transactions to it, adding new records, and deleting obsolete records.

Validation checks. Tests that can be built into computer programs to check the accuracy, completeness, and propriety of input transactions. These checks include character mode tests, field validity tests, authorization tests, completeness tests, and policy tests.

Verification, manual keystroke. A check that uses a second keystroking to verify the accuracy of a key punching operation. The operation is keystroked the second time on a "verifier," using the same source data; but instead of punching another card, the verifier compares the second keystroke with the corresponding hole in the punched card (or paper tape) and signals discrepancies by a machine stoppage.

Verification, visual. Sight comparison between the source document and what has been punched in a card or in paper tape. Printed evidence of what has been punched is required; this is generally accomplished running punched cards through a tabulator. Some keypunch devices, however, print the information simultaneously with punching.

Wire transmission. The facility for transmitting data over wire or radio communication lines, ranging from low speed (such as teletypewriters) up to speeds of hundreds of thousands of characters per second.

Write-protection. A device or method which prevents the accidental erasure of data on a reel of magnetic tape.

Acknowledgements

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Index