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AUDIT IMPLICATIONS OF A POSTULATED
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DISSERTATION

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
School of The Ohio State University

By

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ACKNOWLEDGMENTS

It is almost impossible to prepare a work of this size without aid from many people. I certainly do not claim to be one of those super-humans who is not in need of advice from others.

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entirely my responsibility.
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CHAPTER I

INTRODUCTION

Accounting, as a social science, exists within an ever changing environment. If it is to possess utility, it must remain responsive to changes in this environment.

The past two decades have seen a major, rapid change in the processing of business data. The advent of punched-card equipment and later, computers, made it possible for business firms to process a large volume of data in a reasonably short time. Many clerical operations were converted first to punched-card processing and later, computer processing. These operations were, in general, characterized by a large volume of data with a relatively small number of simple operations performed on each datum.

There has been a steady increase in the ability to express business decisions analytically, making it possible to state decisions as a sequence of relatively straightforward operations. The ability to express decisions analytically has permitted man to write computer programs for the decisions. Decisions which were formerly considered the core of middle management operations, e.g., credit analyses, merchandise reordering, and traffic management, are now being routinely processed by computers.
This use of computers has affected the auditor. An indication of the extent of this effect can be obtained by comparing human and computer data-processing. Human beings are not highly efficient data-processors. They must have relatively extensive training in the specific procedures which they are to perform. As a result, they perform most satisfactorily in those situations involving a high degree of specialization. On the other hand, computers are highly efficient data-processors. A computer is taught to perform an operation by inserting a program into it. The actual process of inserting the program takes very little time and, after the computer reads the program, it performs its assigned operations rapidly and accurately. The degree of specialization in a computer process is a function of the scope and, therefore, size of the program. It, thus, depends upon the size of the computer and the skill of the programmer.

The difference in data-processing characteristics leads one to conclude that the nature of the audit differs in human and computer data-processing. Specifically, there are changes in the nature of the internal controls and the condition of the audit trail which is used when testing the records. The audit trail provides the auditor with the ability to trace transactions from the financial statements back to the original documents and from the original documents to the financial statements. The evaluation of internal controls gives the auditor a basis for reliance upon the records of the firm. Where internal controls are found to be satisfactory, there is a strong implication that the records of the firm are reliable; hence both the
audit trail and internal controls are extremely important to the auditor. They are used when evaluating the validity of financial statement representations.

The specialization required by human data-processing necessitates the existence of voluminous, costly forms as a communications medium. These forms aid the auditor in evaluating internal controls and provide the foundation for the audit trail. Where the forms originate in independent operations, they serve as a means for tracing the flow of assets throughout the firm, as a check on one another and as a check on the employees involved in the transactions. For example, the sales invoices may be compared with shipping documents to determine whether items reportedly sold have actually been shipped. This comparison provides a check on the accuracy of the documents involved. It also validates both sets of records.

A computer, on the other hand, is able to perform many sequential operations without interruption. The need for the communications medium is reduced and, therefore, many documents are eliminated. The results of intermediate calculations are maintained within the computer, or in some computer-oriented storage device, in a form unintelligible to human beings. Many of the intermediate results need not be maintained after they provide a basis for subsequent operations.

Auditors often take an "after-the-fact" approach to these problems. A business firm implements a change; then the auditor examines the resulting system in order to determine how he can perform his audit. The methods used by the auditor are largely modifications
of the methods used when auditing manual data-processing systems. For example, the auditor re-foots journals, traces postings to the ledgers, and examines documents that are available. There is no conceptual reason for believing that these processes are equally applicable in a computer oriented data-processing system.

In order to remove the "after-the-fact" criticism that has been leveled against auditors, a postulated business system is incorporated in this paper. The sole criterion in postulating this system is that it must meet all of the needs of management. No consideration is being given to the restrictions that might be present in a system as a result of economic or technological factors. Removal of these constraints makes it possible to examine the auditing function in an "ideal" system. The conclusions that are reached must be tentative. They cannot be validated by empirical study because no firm can ignore the consideration of economic feasibility and the current state of technology. With these conclusions as a guide, the auditor should be in a position to recognize some of the problems that he will have to face as technological and economic restrictions are removed. Specifically, the auditor will be able to determine how the changes that are made affect his ability to execute the audit function.

It is asserted here that the auditor will be able to perform the traditional audit with a greater degree of confidence in his conclusions. The controls necessary for the daily operation of the business system are such that many of the auditing techniques will be incorporated in the computer program. This means that a continual audit will
take place. If this is so, the auditor's main emphasis shifts from an evaluation of specific accounts to an evaluation of the built-in system controls. This evaluation will determine the extent to which these controls are present and operating and may take place at varying times throughout the business year. The end-of-year procedures may thus be limited to a verification of the firm's reported assets and equities.

One implication of the postulated change is that audited financial statements may be issued to outsiders more quickly than is now customary. The ability to perform the traditional audit with increased confidence and less effort may mean that there will be, or should be, an expansion of the audit function. There is no conceptual reason for restricting the audit function to the verification of financial statements. The evaluation necessary in the postulated system is such that the auditor is in a position to offer an opinion regarding not only financial statements but also the existence of controls assuring adherence to managerial policy or the performance of management.
CHAPTER II

NATURE OF AN AUDIT

Purpose of an Audit

Need for confidence in data

The business firm collects data because the data is useful. In this sense utility must be measured in terms of value added to the decision-making process. Unfortunately, it is not always possible to obtain sufficient data to attain the degree of confidence required by the decision. In these situations it is necessary to determine the confidence that is possible from the available data.

Accumulation of data.—Records are maintained, formally or informally, in response to some need. Certainly the various regulatory agencies provide sufficient motivation for keeping records but, even in the absence of specific regulatory requirements, most business firms maintain some form of records. Since maintaining records involves a real cost for the business, an assumption must be made that records are kept because they add value to the firm. The value of business records, apart from meeting regulatory requirements, is derived from value added to the decision-making process. No attempt is being made here to quantify this value; it appears sufficient to accept the premise on a purely conceptual basis.
Since value is derived from the decision-making process, it follows that the decision-maker must have confidence in the data contained in the business records. Assume for the moment that confidence in the data is lacking. There are three alternatives available to the decision-maker: (1) make the decision without using the data; (2) use the data, but supplement it intuitively; or (3) defer the decision. The first alternative is inconsistent with the premise that data has value, for if it has value, it must have added something to the decision-making process, in which case it cannot be ignored. The third alternative is representative of an ideal state. In this instance management has some preconceived notion about how much confidence in the data it desired. Using this approach, the decision is deferred until the quality and quantity of the data collected are consistent with this preconceived notion. Clearly, the decision to defer action pending the receipt of additional information may not be a realistic business alternative.

Limited availability of data.—It may be impossible to obtain additional data. More commonly, it may be impracticable to obtain the additional data. The impracticality arises from two directions—cost and time. Recall that the accumulation of data is possible only at some cost. The question therefore arises, "Is it better to make decisions based upon incomplete data or should a supplemental, possibly costly, data collection program be started?" In many cases the supplemental program is not economically feasible because the cost of the supplemental data may exceed the value added to decisions. Two
even more compelling reasons exist for discarding the decision to collect additional data. It takes time to collect data. Associated with each decision is a time constraint. Even if it is possible and economically feasible to accumulate additional data, the rapidity with which conditions change makes it impracticable. Bourland states this point very succinctly as his "Weak Law of Large Decisions."

The larger the decision, the less necessary it is to make it, for it will be overtaken by events.

The only realistic alternative is to use the incomplete data, supplementing it with intuitive value judgments.

Objective of the audit

Decision-making based upon financial statements is decision-making in the presence of limited data availability. In a practical sense, the user of corporate financial statements is limited to the data contained in the statements. Since additional data is unavailable, the question becomes "How much confidence may be associated with the representations contained in the statements?" The current state of knowledge does not permit the assignment of a numerical measure of confidence in this case. Instead, the opinion of an auditor—a certified public accountant—is substituted.

The objective of an independent audit is to add confidence to representations made in financial statements. Mautz and Sharaf point out that "auditing is concerned with the protection of those who read

1David Bourland Jr., "Non-Decision Theory, "Datamation, X (May, 1964), 55.
financial statements; its purpose is to assure them that certain
standards of accuracy, clarity, and completeness have been met.²

Professionalism of auditors.—Relying upon others for information
is not unique to this type of data. Indeed, Montague asserts that
people use this method, authoritarianism, as a source of most
knowledge.

We get more of our beliefs from the
testimony of our fellows than from any other
source. Little of our knowledge of the
universe is directly tested by our own
intuition, reason, experience, or practice.
We accept on trust nine-tenths of what we
hold to be true. Man is a suggestible
animal and tends to believe what is said
to him unless he has some positive reason
for doubting the honesty or competence of
his informant.³

He continues by asserting that in the absence of any adverse
information regarding the person making the representations, the
information is acceptable.

It is necessary for an individual to trust
other individuals in matters which he cannot
investigate for himself; and unless there is
some reason to suppose that the witnesses are
biased or incompetent, their testimony should
be put on a par with his own.⁴

²R.K. Mautz and Hussein A. Sharaf, The Philosophy of Auditing

³William Pepperell Montague, The Ways of Knowing (New York:

⁴Ibid., p. 225.
Those assertions are generally true. Many decisions are made in the presence of uncertainty, and one's willingness to rely upon assertions made by others must be accompanied by both confidence in the person making the representations and an expectation of loss attendant to an erroneous decision.

Auditors are able to add confidence to these representations because they are accepted as professionals. The sociologist, Hughes, states that "... professionals profess. They profess to know better than others the nature of certain matters and to know better than their clients what ails them or their affairs." He goes on to elaborate upon the nature of this reliance upon professionals.

Since the professional does profess, he asks that he be trusted. The client is not a true judge of the value of the services that he receives; furthermore, the problems and affairs of men are such that the best professional advice and action will not always solve them. A central feature, then, of all professions, is the motto—*not used in this form as far as I know—*credat empor. This is the professional relation distinguished from that of those markets in which the rule is caveat emptor, although the latter is far from a universal rule even in exchange of goods. The client is to trust the professional; he must tell him all secrets which bear upon his judgment and skill. In return, the professional asks protection from any unfortunate consequences of his professional action; he and his fellows make it very difficult for anyone outside—even civil courts—to pass judgment upon one of their members. Only the professional can say when his colleague makes a mistake.
Confidence in the opinion of the auditor arises from the professional status associated with the title certified public accountant. Numerous examples of this sort of confidence exist. In a recent court case, Judge Thomsen, Chief Justice of the U.S. District Court of Maryland, ruled that it was improper to judge audits performed by government employees by the same standards that one would apply to an audit by a CPA. A recent publication by the American Institute of Certified Public Accountants asserts that "... the characteristic of adding credibility to financial data is so closely associated with the title of certified public accountant that the mere presence of his name is likely to make people rely more heavily on, say, even a statement clearly described as 'prepared from the books without audit' than on the same statement prepared by someone without professional qualifications." Similarly, Montague points out that the reliance upon an authority is often strong enough to cause one to accept a statement made by the authority even where it runs contrary to prior beliefs.

In the affairs of ordinary life our readiness to accept on faith the statements of others is at least in part proportional to our regard for the persons making the statements. If I knew an individual to have been honest and

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truthful in the past, I am more willing to take his bare word on some new matter on which I have no other evidence. If I know in addition to his honesty he has also proved himself an expert in a given field of knowledge, I will accept what he tells me concerning that field as true, even though it runs counter to what I should otherwise have believed.9

To assert that the certified public accountant is a "professional" is to assert that his title implies certain behavior on the part of people who rely upon his services. Note, for example, Nagel's comments:

To say that an object is a tool, for example, is allegedly to say that it is expected to produce certain effects by those who so characterize that object. Accordingly, the various "things" that may need to be mentioned in explaining purposive action must be constrained in terms of what human actors themselves believe about those things, rather than in terms of what can be discovered about the things by way of the objective methods of the natural sciences.10

Similarly, Hayek comments:

Any knowledge which we may happen to possess about the true nature of the natural things, but which the people whose actions we want to explain do not possess, is as little relevant to the explanation of their actions as our private disbelief in the efficacy of a magic charm will help us to understand the behavior of the savage who believes in it.11

Even if the CPA feels that the degree of reliance upon his opinion is

9Ibid., p. 41.


unwarranted, this does not change the fact that such reliance does in fact exist.

The auditor in society.—The auditor has a singular position in society. He is retained by business firms in order to associate his professional status with their representations. To assure himself that he is in a position to add this confidence, the auditor performs a series of procedures called an audit. Interestingly enough, the auditor performs his audit subject to exactly the same constraints that affect the accumulation of data—cost and time. In return for his services, the auditor charges his clients a fee. There is also a cost, implicit or explicit, involved when performing an audit. Thus the auditor must decide how much data it is economical to test and examine before issuing an opinion.

In addition to cost factors, the value of time must be considered. Even in the absence of statutory requirements, the value of the information contained in the financial statements decreases as the time between the occurrence and the reporting of the events increases.

Time is a controlling factor in most audit work; the auditor's judgment is normally required within a relatively short time after the occurrence of the transaction and the other events reflected in the financial statements.¹²

The auditor's objective therefore is to obtain and examine a sufficient quantity and quality of evidence, consistent with time and cost constraints, to enable the issuance of an opinion. The issuance

¹²Mautz and Sharaf, p. 78.
of an opinion is not an absolute act. The auditor can issue various standard opinions, thereby associating himself with the financial statements in varying degrees. In cases where the evidence indicates that the financial statements are misleading, he dissociates himself from them—an adverse opinion. If he disagrees with the treatment of specific items and if these items are not sufficiently material to make the statements misleading, then he limits his association with the statements—a qualified opinion. Where insufficient evidence is available to the auditor during the course of the audit, he states that he is not in a position to offer an opinion—a disclaimer.

Audit Evidence

Gap between events and decisions

In any field of investigation there is some gap between the occurrence of events and the impact of these events upon the decision-making process. The occurrences separating the events and the decisions they motivate may be viewed as shown in Figure 1. There are three steps separating the events and the decision-maker: observation, measurement, and communication. In any one of these steps, certain errors are likely to occur.

Assume that the decision-maker and the person observing the events are separate, i.e., they are not the same person. The occurrence of an event can have no effect unless the decision-maker knows about it. This implies that the occurrence must first be sensed
Decision-maker

Communication

Observer

Symbols

Measurements

Phenomenology
(Observation)

Instruments

Observable events

Observed events

Fig. 1.—The Gap between Events and the Decision-maker.
by an observer. It is possible that the observer will not make a correct observation. One obvious reason for an incorrect observation is the possibility that the observer is unqualified for the task, i.e., he lacks the necessary skills. Even if it is assumed that this possibility does not exist, there is still a possible error at this point. The only way in which an observer can observe is through the use of his various senses, but his senses may not adequately reflect reality. To the extent that this occurs, the true nature of the event cannot be communicated to the decision-maker.

Observation.—A branch of philosophy, phenomenology, deals with the possible differences between sensations and reality. Baldwin defines phenomenology as

the theory of appearances or manifestations; in technical use, that theory of the particular...

... facts of any subject-matter which exhibits them as natural and necessary manifestations of their underlying principles.13

... in modern times the phenomenon is opposed to the THING-IN-ITSELF or NOUMENON. They belong to radically distinct orders; the phenomenon is always relative to us, dependent upon the way the thing-in-itself affects us in sensation or the way the mind looks at it.14

The possibility exists that all observers have distorted senses and hence fail to perceive reality. If this is the case, no knowledge can exist. While all of this is possible, it should be noted that it is

14 Ibid.
generally assumed to be improbable; so improbable that one does not usually differentiate phenomena from noumena. In the particular case where observations are made by someone who is accepted as a professional, it is assumed that there is more skill used in making the observations than would be the case on the part of a non-professional.

Measurement.—If it is assumed that the professional observer adequately perceives reality, difficulties in the overall process still exist. Observation in itself does not provide any basis for the use of the event in decision-making. It is necessary to make measurements. In this sense, the term measurement is used to include any attempt to enumerate the characteristics of a phenomenon. The measurement requires the use of some instrument in order to differentiate between characteristics. Note, however, that the instrument need not be in some tangible form such as a ruler or caliper; it may, and in the social sciences it usually does, consist of nothing more than the critical ability of the observer. Indeed, it is this very fact that creates difficulties in the social sciences. In the physical sciences it is usually possible to separate the observer and his instruments, but in the social sciences this simplicity often does not exist. It is difficult to separate the interviewer from the observer in such a way that there is a clear differentiation between observation and interpretation. If there exists a possibility that the instruments are being incorrectly used, the situation is even more complicated. The instrument here is the observer himself, and incorrect use of the
instrument takes place when personal, and hence biased, interpretations are used in recording the observations.

Any discussion of the nature of measurements leads to the conclusion that the measurements by themselves can provide little or no information. All useful measurements must be accompanied by information regarding the extent of the possible errors in the measurements. It is therefore necessary to talk about the accuracy of measurements. Accuracy is defined as a deviation between the reading obtained when using an instrument and the true manifestation of the event.

This definition seems to imply an a priori knowledge of reality. This is not the case. Churchman points out that "... one of the most significant results of modern scientific method has been the ability to estimate accuracy without knowing exactly what reality is [emphasis mine]." 15 Table 1 shows a classification of errors according to Beers. The definition of accuracy that is being used here includes what Beers separates into "precision" [small random errors] and "accuracy" [small systematic errors]. 16


TABLE 1

POSSIBLE ERRORS IN MEASUREMENTS

Systematic Errors
- Errors of calibration of instruments
- Personal errors
- Experimental conditions
- Imperfect technique

Random Errors
- Errors in judgment
- Fluctuating conditions
- Small disturbances
- Lack of precise definition

Illegitimate Errors
- Blunders
- Errors of computation
- Chaotic errors

Source: Beers, pp, 4-5.

It is apparent that measurements of accuracy are possible once one assumes: (1) that illegitimate errors are impossible and (2) that the event may be repeated under controlled conditions. 17 All legitimate errors are either systematic or random. If they are systematic, it is possible to make adjustments to the true value. To the extent that they are random, the ability to repeat the events makes it possible to utilize statistical techniques for estimating confidence.

17 In a controlled experiment, the experimenter can manipulate at will, even if only within limits, certain features in a situation (often designated as 'variables' or 'factors') which are assumed to constitute the relevant conditions for the occurrences of the phenomena under study, so that by repeatedly varying some of them (in the ideal case, by varying just one) but keeping the others constant, the observer can study the effects of such changes upon the phenomenon and the variables." Nagel, pp. 450-451.
Communication.—Finally, even if the ability to adequately perceive an event together with the ability to make accurate measurements is assumed, one major problem still remains. Unless the observations, and consequently the measurements, are adequately communicated to the decision-maker, they are of no use.

The communications process involves the transmission and receipt of data. Ignoring the possibility of intentionally misleading representations, there are two possible errors in this process, viz., loss of data between transmission and reception, and additions to the transmitted message. The first of these conditions occurs when, due to lack of clarity, the reader is unable to unambiguously determine the nature of the transmitted message. The second, and far more serious, condition occurs when the reader feels that he has been given information while in reality this is not the case.

Nature of audit evidence

Having examined, in a generalized way, the gap between events and decisions, it is now possible to examine the auditing process in the same context. Assume that (1) the observations underlying financial statements adequately reflect reality; (2) illegitimate errors are impossible; (3) events may be repeated under controlled conditions; and (4) measurements may be communicated adequately. Under these assumptions, the auditor is in a position to determine how much confidence he requires before associating himself with the financial statements. He can then proceed until this predetermined level of confidence is reached.
Clearly, in the social sciences and accounting in particular, these assumptions lack validity. Human beings (the main components of most business systems with which the auditor comes in contact) do not possess any inherent quality characteristics. Instead, they must be taught quality control, just as they must be taught the nature of many of the acts which they perform. Thus one may conclude that observations are not necessarily accurate; illegitimate errors are possible; events cannot always be repeated (nor may repeated measurements of the same event always be made); and there is no assurance that the communications process is adequate.

Auditing reality.—In view of the difficulties with these assumptions, the auditor is forced to substitute alternatives. Reliability of financial statements depends upon the adequacy with which they reflect reality. It has already been shown that reality is a nebulous concept that is not easily discernible. The auditor asserts that "... truth in auditing may be defined as conformity with reality as the auditor can determine reality [emphasis mine] at the time of his examination and with the evidence available." Since the auditor is generally constrained to applying his skill in connection with financial statements, his concept of reality is further limited. His skill is generally associated with the application of generally accepted accounting principles. Note, for example, that the auditor must state in his opinion whether or not the financial statements

\[18\] Nautz and Sharaf, p. 85.
conform to generally accepted accounting principles. The auditor thus has a very definite guide toward a concept of reality. To the extent that the observations have been accurate and free from clerical errors, statements prepared in accordance with generally accepted accounting principles are assumed to adequately reflect reality.

**Emphasis of auditing.**—The major problems of measurement and observation errors still remain. The main problem of the audit becomes that of obtaining evidence regarding the quality of the observations and measurements which have taken place. In the search for evidence, auditors do not differ from researchers in other fields. Note, for example, that Nautz and Sharaf state:

> Like researchers in many other fields, the auditor is interested in evidence and obtains it, and studies it before he forms a judgment. The difference between an auditor and a scientist in this respect is that the auditor must use such information as is available.

Unlike the researcher in the natural sciences, the auditor cannot always obtain the additional data necessary to obtain a prespecified level of confidence. He cannot repeat experiments. Instead, he must rely upon what Nagel refers to as "controlled investigation."

> Controlled investigation consists in a deliberate search for contrasting occasions in which the phenomenon is either uniformly manifested (whether in identical or differing modes) or manifested

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20 Nautz and Sharaf, p. 23.
in some cases but not in others, and in the subsequent examination of certain factors discriminated in these occasions in order to ascertain whether variations in these factors are related to differences in the phenomenon—where these factors as well as the different manifestations of the phenomenon are selected for careful observation because they are assumed to be relevantly related.21

He looks for these characteristics that imply the existence of satisfactory or unsatisfactory financial statement representations. More is said about this point in the section dealing with audit methodology.

One cannot conclude that the inability to perform controlled experiments is necessarily a serious defect in audit methodology. There are, however, serious limitations to this method of analysis, viz., the difficulty in ascertaining the relevant variables and then keeping them constant. On this point Nagel points out that "... field experimentation has some clear advantages over experimentation in the laboratory, but it is equally clear that in field experiments the difficulty of keeping relevant variables constant is in general greater."22

The methodology of auditing is the search for evidence—evidence that varies in both quality and quantity.23 Mauts and Sharaf's definition of evidence is accepted for the purpose at hand.

21 Nagel, pp. 452-453
22 Ibid., p. 457
23 Committee on Auditing Procedure, p. 16.
Audit evidence includes all influences on the mind of an auditor which affect his judgment about the truthfulness of the financial statement propositions, submitted to him for review. This concept of evidence is dependent on the influence of events upon the human mind. The meaning of the quality and quantity of evidence are thus conceptually defined in terms of the extent to which the mind of the auditor is affected. It is difficult to quantify the concept because it depends upon psychological reactions.

Audit methodology

Auditing techniques.—Auditors use various techniques when trying to satisfy themselves that they are in a position to add credence to financial statements. Some of these techniques are listed in Table 2. While these are all methods for collecting evidence, the list ignores the differences in quality of evidence. The list may be reclassified according to the philosophical methods of obtaining knowledge. Table 5 shows this reclassification. It is interesting to note the extent to which auditing—an authoritarian process—relied upon authoritarianism. Montague has pointed out that a large part of knowledge must come from reliance upon others.

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24 Mehta and Sharaf, p. 110.

25 A large part of this section is based directly upon Chapter V in R. K. Mehta and Hussein A. Sharaf, The Philosophy of Auditing (Madison, Wisconsin: American Accounting Association, 1961).

26 Montague, p. 39.
**TABLE 2**

**METHODS USED TO COLLECT AUDIT EVIDENCE—UNCLASSIFIED**

- Physical examination and count
- Confirmation
- Examination of authoritative documents and comparison with the records
- Recomputation
- Retracing bookkeeping procedures
- Scanning
- Inquiry
- Examination of subsidiary records
- Correlation with related information
- Observation of pertinent activities and conditions

**TABLE 3**

**METHODS USED TO COLLECT AUDIT EVIDENCE—CLASSIFIED BY PHILOSOPHICAL CONCEPT**

- **Authoritarianism**—evidence based upon the testimony of others
  - Testimony of people
    - Statements of independent third parties
      - (confirmation)
    - Statements of officers and employees
      - (representations)
  - Testimony of documents
    - Documents prepared outside the enterprise
    - Documents prepared inside the enterprise
    - Subsidiary or detail records

- **Mysticism**—intuitively obtained evidence
  - Scanning
    - Books and records
    - Documents
  - Critical review of testimony of others

- **Rationalization**—reasoning from universals to particulars
  - Recalculation by the auditor
  - Existence of internal control
  - Retracing bookkeeping procedures

- **Empiricism**—perceptual experience
  - Physical examination and count

- **Pragmatism**
  - Subsequent actions by the company, officers, employees, customers, and so forth.
He goes on, however, to state that from a purely logical standpoint this is one of the weaker sources of knowledge.

The weakness of the authoritarian method consists first in the fact that authorities conflict, and that there is consequently an internal discrepancy in the method which makes it difficult of application. . . . The second and more serious source of weakness is due to the apparent impossibility of treating authority as an ultimate source of truth. 27

In the final analysis the justification for the authoritarian method rests upon (1) the prestige of the authority; (2) the length of time over which the belief has been held; or (3) the number of adherents to the belief. The prestige of the authority is derived from its reliability in the past. If a person has been honest and competent in his statements in the past, then there is reason to feel that the same would hold true with respect to additional statements made regarding identical subject matter. It may even be true that this same reliability holds for statements made by the authority regarding allied fields. But certainly this correlation need not necessarily hold as the subject matter of the assertion diverges from the original field. Thus, in the final analysis, the justification for the use of prestige rests not upon authoritarianism but upon the empirical testing of the authority's assertions.

If a large number of people agree with the asserted authority, there is a strong indication of the validity of his assertions. This stems from an assertion that there is only one correct way of seeing

something but many varied ways of making erroneous observations. It then would follow that more people observe correctly than in any one of the incorrect manners. One can certainly take argument with this reasoning. Take, for example, the statement: Buddhism is superior to Christianity. Many people would differ with this statement and the fact that there are more Buddhists in the world than Christians does not add convincingly to the argument. If anything, the validity of this concept of authority must again rest, not upon authoritarianism itself, but upon the empiricism or logic of the masses.

Closely related to this concept is the criterion of age. The justification of this criterion rests upon (1) an appeal to sentiment; (2) an assertion that the world is regressing, i.e., our ancestors were wiser than we are; or, (3) an assertion that age is an indication of reliability, i.e., use of the numerical justification of authoritarianism that has just been discussed. It suffices to recognize that while past generations may have indeed been wise, the environmental conditions have changed. There is no reason to believe that their beliefs are equally valid in the changed circumstances.

It may therefore be concluded that the ultimate justification of the authoritarian method rests upon non-authoritarian means. To the extent that the auditor can reduce the gap between an assertion and its non-authoritarian justification, he can obtain added confidence prior to the issuance of his opinion. The fact that auditors rely upon authoritarianism does not impart excessive weakness to the auditing
process since the auditor uses several independent methods to test each item on the financial statements. The risk of not detecting an error is thus reduced. For example, assume that there has been an addition error in an account receivable. The risk of failing to find this error after comparing a trial balance of accounts receivable with the control account and confirming fifty percent of the accounts receivable, is 0.000005.

Some indication of the quality of audit evidence may be obtained by looking to the source of the evidence. The possibility was suggested that erroneous observations are possible. Most people recognize the existence of hallucinations such as those symptomatic of delirium tremens. Nevertheless, human behavior is such that one generally dissociates himself from such occurrences and behaves as if all perceptions adequately reflect reality. Recall that Hayek pointed

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28 The probability that two statistically independent events will both occur is the product of their individual probabilities. Since probabilities are defined on the range from 0.0 to 1.0, the product of the probabilities is always less than or equal to both of the individual probabilities. The product is only equal to one of the individual probabilities if one of the probabilities is 0.0 or if both are 1.0.

29 Fifty percent of the accounts receivable have been chosen at random for confirmation, hence the probability that any single account is not chosen is 0.50. Assume that the accounts receivable all have balances that are expressed with five digits and that any five digit number is equally probable. The probability of having an error that exactly offsets the error in question is 0.00001. Hence the joint probability that both of these techniques will fail to disclose the error is (0.5) (0.00001) = 0.000005.

30 Supra, p. 19
out that the only really important fact in this and similar investigations is how the auditor behaves, and any additional information that may be possessed regarding the validity of this behavior is not important. The auditor does neither himself nor the public any disservice by this reliance upon personal observation. Because of his professional training and status, it is generally assumed that he will perform these observations as well as, and probably better than, a nonprofessional.

Sources of evidence.—The auditor places most reliance upon natural evidence—those things which exist in nature and which are subject to his personal observation. In the absence of this form of evidence he must prepare evidence solely for evidential purposes. Since he is assumed to have superior capabilities in selecting and preparing this evidence, this form is almost as compelling as natural evidence. Into this category fall most accounting analyses, e.g., schedule of aged accounts receivable, that are prepared during the course of an audit.

In the absence of both of these forms of evidence, the auditor must resort to rational argumentation. The quality of evidence is directly related to the influence of the evidence upon the mind of the auditor. Rational argumentation is compelling, but only to the extent that the auditor can follow the arguments or rely upon the person—if other than himself—who presents them. However, arguments that the

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31 Hayek, p. 30.
auditor can follow are more compelling than those which require his dependence on authoritarianism.

**Selection of evidence.**—Three facts indicate that the auditor must be selective in his choice of evidential forms. First of all, the auditor must often render an opinion within a relatively short period of time after the occurrence of events. Secondly, he must perform his audit subject to certain cost limitations. Finally, the confidence generated by the various forms of evidence varies. The selection which is therefore necessary must be based upon some knowledge of the reliability of the various forms of evidence. This knowledge may be formalized but more commonly it is an amalgam of past experience and formal training in "the art of auditing."

**Scope of the audit**

The traditional audit performed by a certified public accountant has been limited to offering an opinion regarding representations contained in financial statements. This has not always been the scope of the audit. Early audits are reported to have consisted of a public reading of accounts receivable in the presence of the townspeople. If the scope of the audit changed once, there is no reason to believe that it will not change again.

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Assume that the scope of the audit will change again. If the current literature is any indication, this change will be a broadening of the function. An extreme in breadth might be reached where auditing is defined as the process of adding confidence to the representations of others. In this sense, the term "representations" need not be restricted to financial statement representations. Whether or not this expanded definition has validity must depend upon the concept that the public maintains regarding the skills of the auditor.

Recall that the auditor is able to add confidence to financial statement representations by associating his professional reputation with these representations. Any added confidence in areas other than financial statement representations must, therefore, rest upon the ability of the auditor to transfer his status to these new areas. This ability is totally dependent upon the opinion of the using public.

In a sense, this reliance upon public opinion suggests that the auditor has only limited control over his own function. If the public behaves as if he has expanded his function, then he may have little alternative but to actually follow suit. The traditional approach to this problem has been through educating the public regarding the limitations of accounting reports and opinion. This approach carries with it a high risk; failure to convince the public that the audit

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33 Note, for example, the recent volume of literature dealing with "management" or "operations" audits

function is more limited than it believes will result in a loss of confidence in the more limited function that is actually being performed. For the same reason the alternative of failing to react to the changing public opinion is equally risky. The third alternative, conceptually valid but consistent with a dynamic profession, is the expansion of the audit function to coincide with public opinion. This alternative carries with it the same attendant risks. It does, however, permit the evaluation of the audit function unrestricted by limitations in scope resulting from historical tradition.
CHAPTER III

NATURE OF A MANAGEMENT INFORMATION SYSTEM

The problem of designing an information system that provides information for many different users is not new to the accountant. When an accountant prepares a financial statement for publication, he knows that it will be used by many individuals: investors, creditors, employees, and governmental regulatory agencies. There is no reason to believe that the needs of each of these diverse groups are identical. In fact, just the opposite is true. How does the accountant get himself out of this apparent dilemma? Attaching a favorable auditor's opinion to the financial statements assures the user that a series of procedures referred to as "generally accepted accounting principles" has been followed in the preparation of the statements. It is assumed that by knowing the underlying assumptions and techniques the user of the financial statements can make any necessary modifications to adapt the statements to his particular needs.

The philosophy followed by the accountant when reporting to outsiders need not dictate the approach to be taken when reporting to management. It is possible that the alternative which best meets the needs in this situation is the preparation of separate reports—each meeting the needs of a specific person in the business.
The Management Functions

The operation of every business may be considered as composed of several functions. Each function is smaller in scope than the overall firm and has an independent objective, but each contributes to the operation of a firm. The division of management into a series of individual functions is a method for simplifying the analysis of the complex whole. Similarly, society itself is too complex to treat as a whole. Instead, an examination is made of its individual components. Economists have used this method for a long time. They postulate a given model, e.g., pure competition, and then examine the effects of varying the individual factors—ceteris paribus.

Before examining the nature of an information system, it is necessary to investigate the functions of management. The investigation highlights the many facets of managerial performance. The number of different, but interrelated, functions indicates the difficulty that must be overcome in obtaining a single information system which meets the needs of all possible users.

Consider the complex called management as divided into four separate functions—planning, organizing, directing and controlling. These functions have been chosen as an aid in delineating specific

1"The term 'business function' refers merely to some particular work that is necessary for the organization's objectives." Ralph C. Davis, Industrial Organization and Management (New York: Harper and Brothers, 1957), p. 43.

systems requirements and are not necessarily independent. Actions in
one function can and do affect those taken in others. They overlap in
scope, perspective, time of performance, and so on.

Planning

Planning is the original specification of broad goals. It
includes those decisions that relate to the establishment of policies
and objectives and attempts to answer the question, "Where are we
going?"

This definition of planning is more limited in scope than the
definitions that have been used by some other authors. For example,
it does not include the specification of the "... factors, forces,
effects and interrelationships in the accomplishment of objectives."3
Neither does it require that the plan be "... detailed enough that
specific attention may be given to its fulfillment in controllable
segments."4 The fact that these definitions differ does not mean that
one definition is correct while the other is not. The purpose of
stating a definition is to eliminate confusion during the communica-
tions process. Within this objective any definition convenient to the author
may be used.

3 Davis, p. 54.

4 James L. Pierce, "The Planning and Control Concept," The
Controller, XXII, (September, 1954), 403.
Organizing

After the goals have been established, the activities necessary to carry them out may be specified and grouped into manageable units. Organizing is the process of specifying the interrelationships needed in order to achieve the goals. It provides part of the answer to the question, "How shall we get there?"

The term "organization" implies an arrangement in which all units are so related to each other that they may work as a whole, each unit having its proper task to perform.5

Directing

The plan of action may be detailed specifically only after the goals of the firm and the organization have been established. The function of "directing" involves the actual delegation of authority. The delegation of authority must be accompanied by a delegation of responsibility to assure control over the actions of subordinates.

"Directing is the use of formal authority in order to guide subordinates."6 This is the first stage at which a concrete plan of action appears in detail which answers the questions "What?" "How?" "When?" "Where?" It takes on many familiar forms. The budgets, procedure manuals, and even inter-office memoranda are parts of the plan of action.

6 Ibid.
Controlling

Controlling is the managerial function which regulates action in accordance with the plans for the achievement of specified objectives. The concept of control is not limited to any one aspect of business activity. Nor does the concept imply any specific methods that might be used to achieve a given result.

The essence of control rests in the comparison of current performance with expectations. Any deviations imply the need for action to reduce the probability of similar deviations in the future. In this context, any deviations, favorable or not, are considered undesirable.

Management Information System Defined

Once the general characteristics of the postulated system have been stated, a comparison is made between the accounting system and the stated characteristics. The purpose of this comparison is to establish the degree of consistency between the requirements of each of the systems. Specification of the data-processing characteristics of the system has been postponed until the following chapter.

Generalized Systems Concept

A description of the accounting system or a management information system rests upon the generalized concept of a system. Instead of

7Davis, p. 125.
8Ibid.
9Tannenbaum, p. 231.
referring to specific forms of systems, e.g., automatic systems, computer systems, or human systems, as do some authors, the approach taken here is to examine the generalized characteristics of all systems. This approach is taken because an attempt to define a subset of a system cannot be made without relating the subset to the generalized concept of a system.

The definition of a "system" presented by Webster is nebulous, but it nevertheless can serve as a starting point.

An aggregation or assemblage of objects united by some form of regular interaction or interdependence; a group of diverse units so combined by nature or art as to form an integrated whole, and to function, operate, or move in unison, and, often in obedience to some form of control; an organic or organized whole. According to this definition, there are three relevant characteristics, namely; (a) a multiplicity of objects; (b) certain elements which unify these objects; and (c) behavior of the system as a single and unified whole. Definitions suggested by other writers have these characteristics in common.


Both the unifying elements and the behavioral characteristics of the system may be summarized by saying that there must be some form of interrelationship present. Assume for the moment that this characteristic is not necessary for the existence of a system. This is analogous to assuming that knowledge can exist apart from a knower—"Does knowledge exist in books?" From a strictly operational point of view, the concept of a system is useful only if the observer correctly perceives the existing interrelationships. The existence or nonexistence of a system is a strictly personal matter, depending upon the perception and insight of the observer. In short,

... a system is any collection of entities of whatever kind, which can be understood as forming a coherent group. In the language of a child or a savage, a line of figures may be a mere collection; in the language of a mathematician, the same line of figures may be a binomial series. ... The structure of a system is its relatedness.

While it is true that the primary characteristic of any system is the existence of interrelationships between entities, there is no reason for requiring more than one entity in the system. Every entity is itself a system; it interacts with itself. This case, however, is rather trivial and uninteresting. The definition of a system as consisting of more than one entity is arbitrary. It results from the fact that single component systems do not generally provide a useful basis for extending knowledge. At the other extreme, the scope of a system is not usually extended without bound. Conceivably, the

entire universe is one system. Yet man, with all of his mental capabilities, is not able to understand and handle all of the complex interrelationships—even if he could perceive them. It is therefore convenient to restrict the scope of any given system to a size somewhere between these extremes. The size of the system exists both by definition and to the extent that the researcher is able to observe the existing interrelationships.

In short, "system" is used here to indicate any set of entities interacting with each other in such a manner that the observer perceives the existing interrelationships. In a practical sense the term system is usually used together with some modifier, delimiting its scope.

Concepts of an ideal system

The hypothesized system should meet all of management's needs. Does this mean that it is an ideal system? In order to answer this question it is necessary to examine the characteristics of "ideal" entities.

Ideal defined

An ideal is "a standard of perfection, beauty, or moral or physical excellence, especially as an aim of attainment or realization; a perfect type, whether a reality or a conception only."\(^{15}\) This definition by Webster states that an ideal is an aim of attainment, i.e., a goal toward which one works. It also admits the possibility that

\(^{15}\)Webster, p. 1236.
this goal may not be currently attainable. For purposes of de-
termining whether the system being postulated should be attainable,
the framework suggested by Nadler is used. He suggests the
existence of three types of ideals: technologically workable,
theoretical, and ultimate.

Technologically workable ideal.—A technologically workable ideal
is an aim of attainment constrained by the current state of technology.
A technologically workable ideal written communication system for a
cave man may have involved the use of stones and some form of a chisel.
A similar ideal in our society probably involves paper and either pen,
pencil or typewriter, depending upon the perspective of the individual
defining the goal to be achieved.

The problem of defining the concept of an ideal based upon the
current state of technology may be related to the cost accounting
problem regarding standards based upon current performance. Both
standards and ideals are gauges against which one may measure per-
formance; therefore, they should enable differentiation between good
and unsatisfactory performance. Because both standards and ideals are
gauges for performance measurement, they should provide an incentive
for the entity whose performance is being measured. Cost accounting
literature generally discards standards set around current performance
because (1) there is no way to determine whether current performance
is satisfactory and, (2) standards set around current performance

Nadler, pp. 44-45
provide no incentive. Technologically workable ideals may be
discarded from further consideration for similar reasons: (1) these
ideals provide the systems designer with no incentive, because they
may be met by current performance, even though that performance is
unsatisfactory for meeting the needs of the system; and (2) as
technology advances, these ideals provide no sense of direction for
the expansion of the system.

Theoretical ideal.—The theoretical ideal represents the other
extreme, opposite the technologically workable ideal. It can never be
attained; it is a tool for reasoning. Feibleman describes a theoretical
airplane design:

What the (airplane) designers have been working
toward is an airplane that will carry an infinite amount
of payload at an infinite speed while itself weighing
nothing at all! This is of course a limit, and like all
such limits, is an ideal intended to be increasingly
approached without ever being absolutely reached. 17

In the context of the management system, the theoretically ideal
system is one which should provide any information that is needed,
when needed, in exactly the form needed, and at no implicit or
explicit cost. This is an excellent goal but, realistically, a
fantasy!

The fact that the theoretically ideal system is unattainable
does not preclude its postulation. It is a goal toward which to work.

17 J.K. Feibleman, "Pure Science, Applied Science, Technology,
Engineering: An Attempt at Definition," Technology and Culture,
II, (Fall, 1961), 305-307.
In the absence of a theoretical ideal, the systems designer has no sense of direction assuring continuity as the system is expanded and improved.

**Ultimate ideal.**—An ultimate ideal system is someplace between the theoretical ideal and the technologically feasible ideal. Goals for the system have been established and definite design characteristics may be ascertained. The "ultimate ideal," however, may not be attained at the present.

More than one ultimate ideal system can usually be developed, all of which can be turned over to the research and development department. When an idea can be detailed with a fair degree of eventual operating certainty, it is *not* an ultimate ideal system.18

The inability to attain the ultimate ideal is derived from two considerations: technological and economic. The current state of technology is such that the "ultimate ideal" cannot be achieved without considerable prior research and development. To the extent that specific components of the system are currently in existence, economic considerations make their immediate employment impossible.

**Choice of ideal.**—The choice of a concept for analysis purposes must rest upon both the objectives of the analysis and the nature of the concepts. An attempt to examine the audit function apart from current procedures immediately eliminates use of a technologically feasible ideal because this concept requires adherence to the present. The theoretical ideal and the ultimate ideal differ (1) in respect to

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18 Nadler, p. 45.
their consideration of economic and technological factors and, (2) regarding the existence of definite design characteristics.

Consideration of systems other than those currently in existence is possible only by ignoring technological and economic considerations. Therefore this difference between the theoretical and ultimate ideals is not useful. The major point of difference is the existence of definite design characteristics. It may at times appear that the postulated system exists solely on a vague conceptual basis. Nevertheless, the fact that general characteristics can be established for the system requires that it be called an ultimate and not a theoretical ideal.

**Information requirements of management**

The management functions differ in perspective, scope and time of performance. There is no reason to believe that the same information is equally useful in the performance of all the management functions. In fact, the opposite is true.

Information which is sufficiently detailed for one function, at a particular organizational level, is not necessarily satisfactory in another function or at another level. A foreman attempting to control the performance of the people within his department has no need for information summarizing operations of the plant taken as a whole. Similarly, the president of the firm has little need for the detailed information required by the shop foreman.
TABLE 4

INFORMATION REQUIREMENTS OF MANAGERIAL FUNCTIONS

Planning—Current and projected environmental conditions
Position of the firm with relation to it's environment

Organizing—Relationships between the various factors that comprise the firm
Formal and informal lines of authority and responsibility

Directing—Relationships between the various factors that comprise the firm
Formal and informal lines of authority and responsibility
Time oriented levels of expectation

Controlling—Relationships between the various factors that comprise the firm
Time oriented levels of expectation
Current performance data

Requirements of a Management Information System

The ability of management to establish realistic goals and then achieve them depends upon several factors. Management must be able to understand the complex interrelationships among the various components of the firm, among the varied functions of management, and between the firm and its environment. The various components of the firm must be able to react constantly and consistently in such a manner that when taken together they sustain the firm's operations at optimum level. A management information system is a system which provides any information required for this continued operation of the firm. The information provided must be timely, comprehensive, reliable and flexible.
**Timeliness.**—The information provided by a management information system should be made available to management at the time that it is needed for the execution of the managerial functions. Information that is available either before or after the need exists has no value because its value is derived from the decision-making process. There can be no value in the absence of a decision.

**Comprehensiveness.**—The management information system should be able to present any information needed for the operation of the firm. Therefore it should include, as one integrated unit, the various data collection and analysis units of the firm, e.g., the accounting system or any statistical analyses originating in the individual departments. The integration of all information requirements within one system eliminates duplication of effort. It also assures internal consistency in information quality and quantity.

**Reliability.**—Reliability refers to the ability of an entity to perform its assigned functions satisfactorily. Management assumes that the information it receives is reliable. This reliability is assured, within limits, in the firm which does not use an integrated system, by the duplication of processes and by the logical interrelationships that must exist between various types of information, e.g., there should be some relationship between the sales and the number of items shipped from the warehouse.

Elimination of the duplicate effort does not necessarily reduce the assumed reliability of the data; a different factor is substituted. Most management information systems with which the auditor
will come in contact are of sufficient magnitude to require the use of an electronic computer. Experience indicates that the computer is very accurate and that many controls may be programmed into the computer to insure the reliability of its operations. Reliability is a measurable quantity. For example, Fein suggests the use of measures such as "lifetime, mean time between failures, mean up-time, percentage up-time, mean repair time, and average failure rate," to indicate the reliability of system components. It may not always be easy to measure reliability, but the possibility does exist. The presence of a computer in a prominent position in the system presents the possibility that it may be used to maintain a continuous reliability measure.

**Flexibility.**—A management information system should be able to react to the changing needs of management. The goals, plans, and procedures used by a business change with time. The management information system should be able to react to all of these changes.

Some of the analyses provided for management are of a hypothetical nature. These are attempts by management to simulate the operating results or position of the firm, under changed conditions. For example, "What would have happened to our sales if we had discontinued product A?" The results that are obtained are valid, ceteris...

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19 A detailed discussion of these controls is found in Chapter VII.

paribus, to the extent that the assumptions built into the simulation model are realistic. In most situations the simulation of decisions such as those requires the use of a sizable computer. The existence of a management information system built around a computer suggests that the simulation capabilities might very well exist directly within the system. All of the data necessary for simulation are readily available within the system.

Summary of the postulated system

This section is a concise statement of the postulated management information system. As a system it must be integrated, i.e., it must consist of entities which interact in such a manner that an observer can perceive the interrelationships. The interrelationships are derived from the constraint that the management information system must be able to provide any information needed by management for the successful execution of its functions—planning, organizing, directing and controlling. At the same time it must be able to satisfy additional requirements of timeliness, reliability, comprehensiveness and flexibility. In short:

1. The information must be provided at exactly the time that it is needed for decision-making.

2. The management information system must be totally integrated, including within its scope all of the information needs of management. Its scope may not be limited by orientation toward any one aspect of the business.
3. Management must be able to assume complete reliability of the information that it receives. Because of the increased reliance upon computers, it should be possible to obtain a measure of reliability.

4. The system must be flexible enough to reflect changing goals, plans and procedures. Because many of the decisions made by management are hypothetical, the system should have simulation capabilities.

It has also been necessary to establish a further parameter before describing the data-processing characteristics of the system. This management information system is an ultimate ideal system, i.e., it exists with definite definable characteristics but does not exist at the present due to economic and technological limitations.

**Accounting as an Information System**

A typical business uses its accounting system as a means for collecting and disseminating information, but the accounting system is not the only mechanism utilized for this purpose. It is, however, one of the more formally structured systems used for this purpose. It provides a natural core around which one may build a management information system.

**Objectives and scope**

The accounting system is used to determine the results of operations, to keep track of the assets and liabilities, to initiate actions, and to facilitate business planning.\(^{21}\) It must accomplish

these objectives subject to the requirements stated for a management information system.22

Each of the management functions—planning, organizing, directing and controlling—makes direct or indirect use of the accounting system. Each of these functions is discussed below to show how it is related to accounting.

First of all, the planning function must take into consideration past performance and current capabilities. The financial aspects of these measurements are available from the contents of two of the major accounting reports—the Earnings Statement and the Statement of Financial Position. Once the goals are established, they are integrated into the accounting system. They provide a basis for using such accounting tools as budgets and standard costs.

Secondly, organizing is directly related to accounting. Specifying activities necessary to carry out the goals and grouping them into manageable units provide not only added components of the budgeting system, but also the basis for performance measurement. Performance may only be measured within a context of expectations established as part of this function.

Finally, the directing and controlling functions of management may be considered together since they are directly related to performance measurement. The financial aspects of the detailed plans are reflected in the budgets of the firm. In turn, the budget

22Supra, p. 52.
implicitly reflects the delegation of authority and its attendant responsibilities. It therefore provides a natural mechanism for the measurement of performance, i.e., for purposes of controlling. Some authors feel that the main utility of accounting is in this area. The accounting reports provide management with "feedback" which may be used for the evaluation of day to day operating decisions.

The same basic data that provides management with a measure of its performance also provides a basis for reporting to those outside of the firm. This is an instance where the common core of data provides information for meeting the needs of two groups, each with slightly different requirements. These differences result from the types of decisions made by each group both within and outside of the firm. A person located within the firm makes decisions regarding the managerial functions—planning, organizing, directing and controlling—although not necessarily at the same time. He is, theoretically at least, able to supplement any information that he receives with first-hand observations or with requests for additional information. On the other hand, a person located outside of the firm makes decisions regarding the performance of the business as whole. He may not be able to obtain supplementary information nor does he have first hand observations that may be used when evaluating the information received.

Limitations of accounting as an information system

In recent years accounting has been subjected to increased criticism regarding the relevance, comprehensiveness, and timeliness
of the information that it provides. To the extent that these criticisms are valid, the accounting system as a management information system must either be revised or supplemented.

Relevance.—The formal accounting system consists of a series of historical cost based transactions recorded in journals, ledgers and reports. There are some notable exceptions to this statement—standard costs and appraisals occasionally find their way into the accounting records. Most of the records are based upon historical costs which are irrelevant to decision-making except to the extent that they are predictors of the future. The more useful costs, current market values, do not usually enter into the system. Because this information is needed for decision-making, it must be accumulated by using supplementary systems. Each of these systems is developed departmentally, i.e., within a single department. There is no assurance that the quantity or quality of data is constant between systems.

Comprehensiveness.—Management controls action within the firm through the use of control systems. Some of these systems are built around the formal accounting structure, e.g., traditional budgets and standard costs. The results of applying these techniques may be mixed.

but they do provide control over actions of the firm, i.e., they indicate deviations from the expected level of performance. On the other hand they are restrictive.

... large deviations in quality, cost or performance, whether they are up or down, are not well received. In addition, getting groups on the track takes precedence over analysis of why some groups are doing better than others.24

Because deviations are considered undesirable, these systems often encourage expenditures during the current period so that the ability to make similar expenditures will exist in the future. For example, a manager may use an excess existing in his budget even though no need exists for a current expenditure. This is done so that the departmental budget is not reduced in future periods.

When a job is made up of separate parts which fit together, small errors accumulating in the different parts may easily ruin the final product. Similarly, the performance of each of the individual departments of the firm contribute to the performance of the firm as a whole. Any system used to measure the performance of an individual department should consider the effect of actions taken by this department upon the whole firm. It should also create an awareness of the effect in the people whose performance is being measured. The scope of an accounting-centered control system encourages narrow-mindedness within

the individual departments. A manager knows that his performance is being measured by deviations from expectations. His objective therefore becomes direct adherence to budgets, standards, and so forth. No cognizance of interdepartmental relationships is developed.

One can hardly expect a broad viewpoint from a manager—whether he is in production, sales or engineering—when cost and performance controls are primarily designed to measure departmental efficiency rather than any impact the department actions may have on enabling the whole company or other departments to achieve overall objectives.25

Timeliness.—Information must be available when it is needed. However, there is generally a time lag between the occurrence of events and the availability of reports relating to them. This lag is due to the accounting techniques in use. For example, sales documents must be summarized, recorded in a sales journal, and then finally posted to the general ledger. These techniques are not necessary to the existence of accounting. Instead, they are reflections of data-processing techniques.

Ideally, information should be available immediately following the occurrence of events. This does not imply that management has use for instantaneous Income Statement or Balance Sheet information. This information is meaningful only within a time context. However, if the need should arise, the ability to obtain instantly this or other information should exist. The need for immediate information is particularly important when unusual events occur, because a firm

cannot afford the time lag necessitated by the traditional reporting system. Information regarding these events often reaches management rapidly, through channels not directly related to the formal reporting mechanism. The system proposed here should be capable of providing this information on a timely basis, thus permitting management to place the same confidence in this type of information that it does in all other information.

**Flexibility.**—The accounting system is not able to adapt to rapid changes in managerial needs or expectations, for there is a considerable time lag between the change in expectations and the implementation of these changes in the budgets or standard cost system. This lag is not due to any inherent weakness in the accounting system itself, but is the result of the data-processing techniques in use. Given the practical ability to implement these changes, it is probable that accounting would respond.

**Conclusions**

A management information system provides information—data that is useful for decision-making purposes—to management. It should be able to supply any information required for the execution of the managerial functions. In addition, the information must meet criteria of timeliness, reliability, comprehensiveness and flexibility.

The accounting system of the firm, a formal structure for the collection and manipulation of data, provides a natural framework for a management information system. It does, however, possess several
limitations that require modification before it may be adapted to this purpose. These limitations are not inherent in accounting itself. They are, instead, the result of the data-processing techniques around which the accounting structure was built.
CHAPTER IV

SURVEY OF REAL-TIME SYSTEMS

The objectives which the postulated system must meet have been set forth in previous chapters. Before one can proceed to a discussion of the auditing implications of such a system it is necessary to examine the data-processing characteristics of the system. This follows directly from the need to obtain confidence in the financial statement representations, since the accuracy of the representation is a function of the means used for processing the data. Discussing auditing in the absence of data-processing considerations would imply an independence of financial statement representations and data-processing methodology that does not exist.

Discussion of data-processing characteristics is complicated by the premise underlying the postulated system. The data-processing characteristics used, and hence the equipment configuration, are determined by the joint action of enterprise needs, enterprise resources and the current state of technology. Thus delineation of the specific equipment configuration is inconsistent with the previously established objective of ignoring these factors.

An alternative approach to this problem is thus taken in which a specific type of system—real-time—is discussed because it possesses many of the characteristics of the postulated system. The postulated
system possesses real-time characteristics and to this extent the examination of currently existing real-time systems yields both an understanding of the concepts involved and an indication of the potential capability of the system to meet more strenuous requirements of the future.

Outline of the chapter

Within this chapter a discussion of real-time systems is presented. It is logical that such a presentation be started by defining the nature of the subject matter. A real-time system is defined to be any system which processes data in such a manner that the data is available when it is needed. By this definition, most of the processing that is currently taking place falls into the definition of real-time. The questions, that are neither answered by the definition nor can they be on the basis of presently available evidence, are whether the current data-processing rate has determined the decision-making need for data or whether the rate at which data would be requested would change given the ability to prepare data at any needed rate.

Having defined the nature of the time constraints, the operational characteristics of the system are presented. Included in this classification is a presentation of the nature of the input and output facilities, data transmission facilities and, finally processing capabilities. All of these combine to imply the existence of certain general equipment configurations and programming systems.
The most important benefit to be derived from the existence of real-time systems is found in an evaluation of the reliability characteristics that must exist to permit the existence of the remaining system. These characteristics are presented in some detail in both this chapter and the chapter which deals with the auditor's methodology.

Nature of Real-Time Systems

The alternative to the real-time system, is not as one might believe, a false-time system. Instead, using the jargon of the data-processing area, the opposite, or nonreal-time system is a "batch process" system. Herein lies but part of the difference between what might be called a more traditional system and the real-time system. The full difference goes deeper.

Real-time defined

Rather than jump head-first into a hair-splitting definition of real-time systems, an alternative approach is taken. The actual discussion of the definition is postponed until after the reader has developed an intuitive concept of "real-timeness." This approach is developed by briefly describing several currently existing systems that are generally considered, in the literature, to possess real-time characteristics. Only after this has taken place will there be an attempt to discuss those characteristics that differentiate real-time and nonreal-time systems.
Airline reservation system.—There are now approximately twelve
computerized airline reservation systems in existence.¹ Perhaps the
most publicized of these systems is the American Airlines SABRE system.
For this reason, emphasis is placed on this particular system.²

Using remote agent sets located throughout the country, inquiries
and reservations are entered into a random access computer system
located in the New York area. This computer maintains an inventory of
available seats on all American Airlines flights for a period one year
in advance. In addition the computer maintains information regarding
such additional items as (1) flight schedule changes, (2) passenger
names and telephone numbers; and, (3) confirmation status where the
passenger is making connections with a different airline.

Upon receipt of an inquiry regarding the availability of a seat,
the inventory is immediately reduced and the relevant seat placed in a
suspense account. This is necessary since there is a short interval
between the display of information to the reservation clerk and the
decision by the potential passenger to either accept the reservation,
purchase his ticket, or cancel the entire transaction. Failure to
remove the seat from inventory during this interval could result in
the sale of the seat to another passenger during this interval.

¹Richard E. Sprague, Electronic Business Systems (New York:
²A detailed analysis of the system is found in James D.
Gallagher, Management Information Systems and the Computer (New York:
If the potential passenger decides to either accept the reservation or purchase his ticket, his name, phone number and ticket information are entered into the keyset. Reliability of this information is provided by visual/oral verification of the validity of the flight information.

The recorded information may be recalled or modified at any time. In the event of changes in the flight schedule, the operator keyset may be used to obtain a passenger list together with the phone numbers at which the passengers may be notified. Prior to flight time a similar request provides a boarding list.

Sprague points out that the reservations system provides, as a by-product, considerable additional information on scheduling, reliability, operating efficiency, sales and accounts receivable—all at little more than the cost of the initial reservation system. He also suggests the possibility of the future development of a system where all or many airlines share the same central processor and memory bank, thus facilitating solution of the problems associated with passenger flights using several independent lines. Information in such a set might be provided by the use of pre-punched inquiry authorization keys which would permit the individual airlines to maintain control over the dissemination of their internal information.

3 Sprague, p. 90.

4 Ibid., pp. 76,90.
Savings bank installation—As far back as 1958, the Howard Savings Institution, Newark, N.J., began planning for the full automation of the teller-information function. This and similar banking systems are particularly interesting because of both the nature of the systems and the stringent reliability concepts that are usually associated with banks.

The Howard system connects all of the tellers at all of their branches with the central processors via high-speed telephone lines. Thus a savings or loan customer can conduct all of his business at any one of the bank's branches, with any teller authorized to make entries in his passbook.

Teller keysets, one to every two tellers, are capable of performing the following functions:

1. Interrogation of accounts for balances and/or peculiarities.
2. Deposits or withdrawals
3. Interest posting
4. Step conditions
5. List summaries and/or special transactions.

This last function is only possible after a special supervisory key has been inserted.

Reliability considerations are the most interesting aspect of this system. All teller sets are associated with cathode-ray tube devices—television sets if you like—which display to the teller the...
authorized signature for the account being processed. There is thus little danger due to the unavailability of signature verification sources. While it is still possible for errors of this type to take place, the associated risk is no greater than it was under the manual system. The risk may even be reduced since the tellers need pay less attention to details such as finding ledger cards and may thus concentrate on the more critical areas such as signature verification.

Processing is carried out using two computers, one for real-time processing and a second which, while available for possible use in the event that the primary computer fails, may be used for nonreal-time activities. Information is stored both within the high-access-speed memory of the computer and associated magnetic drums and on lower-access-speed tape. All transactions are recorded on the tape, together with a periodic dump of the contents of the higher-speed memory. It is thus possible to recapture an existing situation after an error has been detected. In addition, agreements have been made with neighboring banks to provide emergency interim processing in the event of a total catastrophe.

While there are plans to utilize the system for the processing of accounting information, such as general ledgers, as a by-product of the customer transaction processing, this has not been implemented beyond having a management console installed in the president's office so that he can maintain instantaneous control over the total deposits, withdrawals, and so forth.
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The SAGE system.—The SAGE (Semi-Automatic Ground Environment) system is currently being used as a major part of our national air defense facilities. It is primarily a large scale communications device which provides for surveillance, identification and, within limits, weapons direction.6

The system surveys the airspace, gathering data from long-range scanning radar, gap-filler radar, height finding radar and airborne radar. This data is correlated with previously filed aircraft flight plans showing the location of commercial and military aircraft. Uncorrelated data is forwarded to control centers for launch of aircraft, preparation of NIKE systems and further attempts at identification. Identification is attempted by voice and visual means through either the Air Movement Information Service or the Strategic Air Command. In the event that identification attempts fail, SAGE communicates with sector airbases to determine the number and status of weapons and to initiate an intercept by manned aircraft. Midcourse guidance of interceptors is also under the control of SAGE. In addition, it decides on the proper mix of weapons.

Reliability of the system is provided by parallel operation of components together with automatic switching in the event of failure, construction of programs as a series of subprograms (each about 6,000 instructions long) which may be individually tested, and extensive

pre-installation and on-site simulation to insure performance of the system as a whole.

**Missile-testing monitor.**—The Pacific Missile Range is currently in operation, providing capability for communication, processing display of data and limited decision-making. Currently the range must provide for (1) a Sea Test Sub-Range ranging from Point Mugu west for 500 miles, used for development and training with air-to-air, air-to-surface, surface-to-air and short range surface-to-surface missiles; (2) an IRBM Sub-Range extending from approximately the same position west for 1,500 miles; (3) an ICBM Sub-Range; (4) a Polar-Orbit Sub-Range for launching into polar orbits; (5) an Equatorial-Orbit Sub-Range for launching satellites eastward from Pacific Islands near the equator; and (6) an Anti-Missile Missile Sub-Range for the development of these devices, using as targets missiles launched from the West Coast of the United States.

In connection with the overall mission, the system must provide support for decisions regarding range safety, impact and recovery prediction, tracking, orbital vehicle control, data handling, pre-launch checkout and post-launch analysis of data. While the system is primarily oriented toward data handling, the time-risk factors of the operation imply the need to have many decisions semi-automated since human beings are unable to respond within the necessary time interval. There must be a balancing of the man-machine interface. For example,

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the system provides for manual override by the range safety officer—subject to time constraints. In the event that either override does not take place by the expiration of a predetermined time interval or deviation from expected trajectory is in excess of some predetermined limit, destroy signals are automatically transmitted by the computer portion of the system.

The presentation of several currently existing systems has served to present those systems which are recognized in the literature as possessing that characteristic which is called real-time. While the scope and sophistication of these systems varies, two observations are possible. There is wide variance in the extent to which the systems lean toward "total" automation. Perhaps the two most extensive and sophisticated systems—the SAGE system and the Pacific Missile Range system—are best indicative of the extent to which business firms may be able to move in the direction of total integration. At the same time these systems come closest to our assumption of ignoring both current technology and economic considerations.

Real-time characteristics.—In its original usage, the term real-time referred to a relationship between data-processing and physical operations. In this sense, an operation was called "real-time" if the results of data-processing were available prior to the completion of a physical process. For example, computer controlled tooling is generally classified as a real-time process since the computer senses and analyzes deviations from the expected process during the course of the process. Thus, under computer control, corrections can be made to compensate for
these deviations before the process is completed. Real-time systems, thus defined, constitute a closed-loop cybernetic process in which deviations are sensed, analyzed and then corrected.\(^8\)\(^9\) Application of this concept to both the physical process and the business system is presented in Figure 2. Note that this illustration does not assume that the decision model in use is fault-free.

In the physical sense used above, there is little confusion about the term real-time processing. However, when one attempts to remove it from this context into a managerial-decision-making context there are, understandably, additional difficulties. How fast must business data be processed to be called real-time? Certainly the results of a business operation must be available to management in a timely manner, i.e., soon enough to be useful for decision-making. Thus Remington Rand is led to state, regarding their UNIVAC 490, that:

... the real-time concept is the fulfillment of management's desire for a method of revising the direction of a business curve before it gains momentum and attains black and white finality. Up-to-the-minute indications of business activity enable the real-time user to detect the suggestion of a downturn and correct it immediately.

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\(^8\) Note that a simple example of this type of mechanism is a thermostat which constantly measures temperature. When the temperature rises above some predetermined point, cooling action takes place either by closing off the heat source or starting a cooling mechanism. Similarly, a drop in temperature below a specified level results in the commencement of heating action.

Figure 2.—Example of Closed-loop Cybernetic Process
in much the same way as a guided missile's course is adjusted as it hurries to its target. 10

Implied in this statement is the supposition that all business curves are unfavorable and hence need revising. This is obviously not the case.

Another writer attempts to differentiate between real-time and nonreal-time processing in terms of discontinuities in a function mapping processing time into utility. 11 (See Figure 3) In this presentation only those functions possessing marked discontinuities caused by a loss of time would be considered real-time, i.e., only those situations where one might be led to use the phrase "time is of the essence." Thus in a nonreal-time system, there is a gradual loss of utility over some time interval \([t, t + dt]\) after which there is perhaps an increasingly rapid loss of utility. Compare this with a real-time system in which there is no, or almost no, loss of utility as long as processing is completed within the interval \([t, t + dt]\) and thereafter a sharp drop.

Use of this model, says the author, leads one to call the airline reservation system (usually considered a real-time system) to be called a nonreal-time system since there is only gradual loss of utility as the potential passenger gets increasingly annoyed while

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Figure 5.—Real-time and Nonreal-time Characteristics
awaiting his tickets. A total loss of utility, of course, takes place when the plane takes off while the potential passenger is still standing at the ticket counter waiting for his ticket. On the other hand a payroll system (usually considered to be nonreal-time) must be considered to be real-time. Assume that a firm pays its employees every Friday. It makes little difference whether the checks are ready Monday, Tuesday, Wednesday, Thursday, or Friday, as long as they are ready on Friday. If the checks are not ready on Friday, there is a sharp loss in utility in the form of employee discontent.

The naive explanation of Laden and Guildersleeve provides little more information about the nature of this process:

In solving a problem, real-time processing is a speed sufficient to give an answer in the actual time during which the problem must be solved. Perhaps in their naiveté they do suggest a direction. The differentiating characteristics of Steel do not help. Time utility must, by definition, be measured on a time scale. At the same time the losses in utility, even in his nonreal-time case, do not take place continuously. Instead there are discrete changes in value. Thus the apparent continuity or discontinuity is as much a function of the time

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12 Ibid., 26.


14 In the airline reservation system that he presents it is probable that the potential passenger does not worry continuously about time to the exclusion of all other factors. Instead, his annoyance builds up discretely as he notices the progression of time.
scale being utilized as it is related to the nature of the process.

The utility of data for the decision-making process follows similar patterns. Since decisions are made in a continuously changing environment, the data used as a basis for these decisions must be available at or prior to their need—certainly not after. If the data is not yet processed at the time when the decision must be made, management has no alternative to making the decision without consideration of the data. Thus all data used for decisions is by necessity real-time. In the context of this discussion the phrase real-time is used as an extension of the previously stated requirement that "information must be provided at exactly the time that it is needed for decision-making." 15, 16

While one generally differentiates between real-time and nonreal-time systems on the basis of whether or not batching of original data takes place, this criterion is not necessarily valid. The ability and/or capability to batch is determined by the nature of the problem, the existing system time constraints and the scope of the overall system.

In the brief description of the Pacific Missile Range, it was stated that there is a need to shift part of the decision function of

15 See p. 49.

16 This usage is not entirely consistent with the literature since the phrase is generally used only in connection with those situations where the interval between the sensing of data and its need for decision-making is extremely short. Thus the literature can be taken to be a specific instance of the criterion presented here.
the system to computers since human beings are not able to react within
the system constraints. It seems doubtful that this will take place in
business data-processing. Nevertheless the size and scope of the
postulated system would be such that routine decisions can be executed
by the computer—the same computer which would be necessary for
real-time processing. Thus one would be increasingly placed in the
position of extreme reliance upon the computer. 17

Components of the system

In this section the hardware characteristics of real-time
systems are presented. As a by-product of real-time processing there
is generally an enlargement of the scope of the system to encompass
more and more of the business functions. For this reason, many of the
characteristics that are presented are included because they accompany
real-time processing even though they are not strictly required by the
time constraints.

Input and Output

An analysis of the input/output characteristics of these systems
requires presentation of both the nature of the data and the specific
equipment that is available for its handling.

17 This does not necessarily imply that the reliance is any
greater than that required in a manual system. It does, however,
raise the question of the ability of the system to perform under
conditions of central computer failure. See the discussion of the
Howard Savings Institution for a description of how one firm proposes
to meet this problem.
Message characteristics.—In any given business there is a variety of both kinds of data and contexts in which it is found. Consider, for example, employee payroll information which may be found in master employee records, period time cards and job time cards. This data originates from different sources, within different contexts and it occurs with different frequencies. For this reason the first step in the development of a system, given previously determined systems objectives, must be an analysis of the data-message characteristics. Omission of this step prohibits the intelligent discussion of data transmission, storage and processing.

The evaluation of message characteristics should include an analysis of both message types and priorities. In this usage the phrase "message types" refers to such items as type of data, size of message and—most important—a frequency distribution of messages. This latter characteristic is most important since a system operating under severe time constraints is not able to purchase additional time from other sources to make up deficiencies. For the same reason, when evaluating the message frequency distribution emphasis should be placed upon peak processing requirements rather than average needs.

There should be consideration of message priorities since the simultaneous occurrence of stimuli from several remote units requires that a choice be made regarding the priority of processing.

18 This illustrates the need for a preliminary specification of system objectives since the message priorities are a function of both system objectives and logic of a given problem.
In this sense, one classification, emphasizing the consideration of both message frequencies and message priorities, might be:

1. Peak messages—high time priority
2. Nonpeak messages—high time priority
3. Nonpeak messages—low time priority
4. Nonpeak messages—special

Included in this last group might be information requests from executives or changes in system parameters.

The priorities of messages are determined by system objectives and the frequency distribution factors mentioned earlier. In general, establishment of priorities must consider such factors as (1) action type, (2) precedence rules based upon prerequisite tasks, (3) time requirements, (4) equipment status, (5) preemption possibilities and, (6) economy.

**Input/output units.**—Once the system message characteristics have been determined, then and only then, can one consider the electro-mechanical devices that are available for getting the data into and out of the electronic system. Available within this context are devices such as typewriters, card readers and punches, tape (magnetic and paper) units, cathode ray tubes, source data sensors, and management consoles. This latter classification includes those combinations of devices, e.g., typewriters and cathode ray tubes, that are constructed to

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19 Included within this classification are any devices that sense data directly from its sources without apparent human alteration or translation. Thus thermostat-like heat sensors or optical scanning devices would be included within this group.
provide either information for executive decisions or capability for processing managerial directives.

Data Transmission

For the purpose at hand the process called data transmission is limited to that action on data taking place between the components—input, output, storage or processor—or the system. Thus this process does not include consideration of the means used to sense the data, process it, or communicate the results to the user.

Nature.—Given that the data has been sensed by an input device, how should it find its way into the stream of processing? While one might visualize a situation in which all problems are simultaneously fed into and processed by the system, this is not realistic when speaking about currently existing systems. Thus there must necessarily be some established priority among data sharing the same limited facilities. A parallel may be drawn between this situation and the economic problem of allocating scarce resources. The limited transmission facilities must be allocated between the many input units contending for their use.

The problem of message processing is divided into two separate portions: (1) the problem of obtaining messages from the input units—polling—and (2) the subsequent processing of these messages. Within the scope of data transmission, only the first of these considerations is treated.

The simplest procedure for testing input units for the existence of messages is called the roll call method. This approach coincides
with the intuitive concept of a roll call in which each entity is called in accordance with some predetermined sequence. In the simple case of a person calling the attendance roll, the affirmative response of an individual is indicative of his presence. Similarly, the transmission of data from a polled unit is indicative of the desire to transmit. This method has the very obvious limitation of requiring a sequential polling of all units without consideration of message-unit relationships and frequency.

An alternative to the simple roll call exists in the contention method. Using this approach, a list of units contending for the use of the shared transmission facilities is maintained in storage. When there exists a capability to process transmission, this list is interrogated and transmission may proceed. While the contention polling method involves more complex programming, it embodies more flexibility in polling sequence.

Processing

The processing segment of the system encompasses the storage, manipulation and alteration of data, although this is by no means the most satisfactory grouping for subsequent analysis.

Routing.—Once a message has been transmitted from a polled unit, it is placed in a temporary storage unit or area, i.e., a queue awaiting further processing. It is possible to maintain several different queues simultaneously, e.g., queues ready for further processing, queues of partially processed data awaiting further information, or queues of low priority items awaiting low activity
periods when they can be processed without interfering with the more
time-constrained activities. Within each queue the data may be
ordered by time of arrival, some minimum delay criterion, or some
optimum memory access time criterion.

Queues are processed (1) when the currently executed process is
terminated; (2) when an interrupt is detected, whether the interrupt
results from an interval timer or from the nature of the processing;
or (3) whenever there is a change in the queue. Processing within the
queue may take place on a FIFO basis, according to predetermined
priority, or on a dynamic basis determined by equipment availability,
time requirements and economics. The FIFO mode of processing, while
having the advantage of simplicity, fails to recognize the varying
priorities of messages. Similarly, the basis which uses priority as
the sole criterion of choice can, theoretically at least, result in a
situation where low priority items in the queue are never processed.
The compromise, dynamic servicing, while not being subject to these
criticisms, has the disadvantage of complexity with its related costs.

**Memory requirements.**—Feasibility of real-time processing, with
both sizeable scope and highly restrictive time constraints, depends
upon the existence of high-speed readily accessible memory. At the
same time one must recognize that the memory, as with all other parts
of a business, is achieved only at some cost—where cost, in this
case, can vary from a fraction of a cent to a million dollars or more.
These units may also be classified according to access time, the time
required to obtain information from memory. Access time varies to
extreme degrees. For example, the time necessary to obtain data from the magnetic core of the IBM 360, model 70, is about 0.2 microseconds. At the other extreme the access time for the data contained on a punched-card is dependent upon the location of the card at the time the data is needed. It can range from 0.1 second (assuming that the card is in position to be read on an IBM 1403 card reader) on up. In this case, up can be quite sizeable if the required card is in storage in some geographically remote place. Finally, memory units may be classified according to storage capacity, which range from 80 characters per punched-card to the literally billions of characters that may be stored on either disks or tape units.

The choice between the available memory units must be made on the basis of cost, timing and programming requirements. Cost considerations are not discussed here since they bear little relationship to the postulated system discussion and since the analysis of these factors is not conceptually different from any other capital budgeting decision.

It is intuitively apparent, from the preceding discussion, that there is a sizeable coordination problem associated with this form of system. Timing factors thus become critical and require primary consideration in the choice of memory units. These timing

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21It was asserted in the discussion of the definition of real-time processing, that there are time constraints associated with all forms of data-processing. The important point, here, is that as the lag between the occurrence of events and the processing of resulting data decreases, the sensitivity of the entire system to those time considerations increases proportionately.
considerations depend solely upon the nature of the item in storage and the use which is to be made of it. If one classifies stored items as programs, primary data, recovery data and temporary communications storage, it is immediately apparent that these items require different cognizance of time factors.

In the determination of storage requirements one cannot fail to consider the requirements of the program. For the purpose of this presentation, programs may be divided into two groups, permanent and temporary, depending upon the length of time that they occupy central storage space. Of the items that are permanently in the central storage unit, none is more important than the executive program itself, for this program constantly "monitors" the operation of the system as a whole.\(^{22}\) The efficiency of the entire processing system is dependent upon the efficiency of the executive program. More will be said about this program and its operation in the section of this chapter dealing with programming requirements.

Permanent storage must also be occupied by certain reference tables needed by the system. These tables may include a list of valid entities, in which case the list is part of the reliability checking function of the system. It may also include the locations of data. This would be the case if, as is often the case, data is stored in high speed auxilliary storage in the order of its entry into the system.

\(^{22}\)The fact that a given program is located in permanent storage does not imply that the program never changes, it merely asserts that the program in one form or another, is always present.
At the other extreme, from programs that permanently occupy primary storage, are the programs that are only temporarily in this position. These programs are not permanently in primary storage either because they are used only periodically or because the program itself is too large for the form of storage. In the latter case program overlay procedures are utilized so that the program is run in segments, with relevant information transmitted from segment to segment.\footnote{For a detailed discussion of the techniques presented using a GE 225 with 4,000 word memory, see Joe A. Phillips, "Inventory Control Without Batching," Datamation X (January, 1964), 45–49.}

In this section there has been a sketchy picture drawn of the many consideration involved when one attempts to install a large scale system that is subject to severe processing-time limitations. The objective of presenting the picture has not been to make the reader into an analyst capable of installing such a system. On the contrary, it has been solely to create the connotation of complexity in comparison to some of the systems with which the reader is already familiar.

**Equipment configuration**

Given the objectives and complexities presented above, there are many different ways that one may organize his equipment to meet these needs. In this section are presented some alternative configurations. No attempt is made to choose between them since the final determination
will inevitably be dependent upon the needs of the specific business application.

Simplex systems.—The simplex system (Figure 4) is conceptually the simplest system. It is the least costly, in terms of hardware considerations, of all the systems considered. At the same time it is the least reliable and least efficient. Since a simplex system is organized in series, failure of any one component implies failure of the entire system. During any maintenance operation the entire system must, therefore, be out of use. Similarly, recovery of data obtained during periods when the system was out of use must necessarily be through manual means since no equipment was available at the time the data was obtained.

Master/slave system.—If one assumes that the objective of increased processing ability is of primary importance, then a possible solution is to add an additional processor in a master/slave relationship (Figure 5). All housekeeping, scheduling, communications and preliminary processing is performed in the master, medium-sized computer. The entire package of program and preprocessed data is then turned over to the larger slave computer for calculating. Results are returned to the master for formatting and output communications.

This system provides increased processing capabilities with a slight increase in reliability (the master can operate if the slave fails). At the same time the additions are secured at increased cost and greatly increased program complexity.
Figure 4.—Simplex System

Figure 5.—Master-slave System
Duplex/multiprocessing system.—In the most advanced system currently existing, one finds several completely separate hardware systems operating simultaneously (Figure 6). While these systems have a high cost and complexity, this may well be offset by the added reliability of parallel structure and the added capability of processing several separate or related programs simultaneously.

Programming Considerations

It is necessary to present a brief view of the programming considerations of real-time systems so that the reader's concept of system complexity is increased. The need to keep the system and the programming task manageable in the face of complexity results in standardization and compartmentalization that adds reliability beyond that found in manual systems.

Factors to be considered

In an attempt to draw attention to the complexity of the overall process a brief discussion of the system scope and complexity is presented. This presentation is followed by an outline of modular programming, the major technique through which standardization and compartmentalization is obtained.

Scope.—Real-time programming, by itself, does not carry with it any implications regarding the size of the system. This follows from the assertion that there is, operationally, no meaning to the phrase real-time since all problems must be solved subject to some time constraint. However, in the current usage of the phrase to imply
Figure 6.--Duplex/Multiprocessing System
extremely fast processing, using large capacity equipment, there is
the implication of complexity. This complexity is derived from the
attempt to utilize the fixed capacity of the equipment as efficiently
as possible.

The structure of the system is derived from the number of
different types of transactions which must be processed together with
the implied timing considerations. As pointed out earlier, the timing
factors, in turn, depend upon the frequency of transactions (especially
at peaks) and the communication coordination problem. It is further
complicated if cathode ray devices are used for either input or
output since the image appearing on these devices fades out and must
be regenerated several times a second.

Programming implications.—It is intuitively clear that the
scope and complexity of the system requirements imply the existence of
an extremely large, complex program. It is likely that increases in
the scope of the program geometrically increase the size of the program
since each scope increase brings with it coordination difficulties.

To coordinate the program one must recognize several character­
istics that must be present:

1. The program must be written. In view of the asserted size of
the program, it is probable that this task must be divided among
several programmers. This requirement suggests the need for the next
two factors.

2. Somebody must be able to understand the system "as a whole."
This does not imply that such visualization is easy, nor does it imply
that this individual must understand the intricate workings of each segment. It requires only an ability to visualize the effective interaction between the segments.

3. The division of programming labor complicates the ability to coordinate the various parts of the program to maintain consistency. This implies the need for standardization and for a central data and programming file which delineates the existing interrelationships.

4. From time to time it becomes necessary to make modifications in the programs and/or in the structure of the entire business system. Such changes are necessitated by changes in scope, policies and objectives, or environmental parameters.

The requirements specified above lead one to the use of modular programming as the best solution known to date. This technique is described in the following section.

Modular programming.—Each transaction in a real-time system can occur at any time (from the system's point of view), and thus the central processor requires access to many programs, each in a random sequence. Given that transactions or requests for information may occur in random order, it is necessary for the processor to determine the type of transaction received and then associate the data or request with the related programs. This is the concept called modular processing.

Modular processing is used to divide a process or program into its logical parts so that each may be treated separately. Using this technique, a building block is created in which each complex problem is
treated as a series of smaller, independent problems. The various smaller parts are interrelated by an executive program (monitor). In essence, this approach is similar to that followed in the manual processing of business problems in which the type of problem being processed is first determined by some executive, and then various aspects of the problem are assigned to specialized personnel.

In order to more thoroughly understand the nature of this type of processing, it is useful to examine the characteristics of each of these segments—the monitor and the individual programs. The monitor makes all decisions regarding the flow of data to the processing programs. No other program may alter this flow, i.e., no program may transfer control to any processing program. The monitor also handles all functions that are common to several programs. For example, the monitor should contain proper initialization routines, handle input/output where the data affects several different processing programs, and arrange for any finalization necessary, e.g., transfer to error diagnosis routines.

The individual processing programs have specialized characteristics. A separate processing program is created for each logical segment of the program. Each of these programs accomplishes its task without aid from other programs. Because each of the processing programs is separate, each is complete within itself. This implies that a separate area within the memory of the computer must be defined for each program, and decisions made outside of the program will not determine processing within the program. Essentially, each program
is designed like a closed-end subroutine, i.e., control is transferred to it by the monitor and, when it completes its assigned tasks, it transfers control back to the monitor.

**Reliability Considerations**

No system, of any type, can long exist without meeting some standards of reliability. In the engineering usage of this term, reliability is the probability that a component will not fail in a stated time interval. Thus, for their purposes, engineers can place reliability within a context such as average lifetime or mean time between failures. No similarly easy concept of reliability exists in business information systems. One can state that reliability is the probability that data is used for its intended purpose, but this does not provide any information regarding the evaluation of this measure. Nevertheless, the concept is used here since it does provide a model within which to reason.

**Importance.**—In a real-time system the computer occupies a central position. Never before (with the possible exception of a one-man business) has there been a system that was so dependent upon a single central structure. It is clear, from an examination of the probabilistic nature of systems performance, that reliability is less in the case of series systems and greater in the case of parallel systems—ceteris paribus. Thus the reliance upon a single control structure adds a series element to the system which, except by greatly
increased reliability of that central component, can greatly decrease the reliability of the system as a whole.

The central importance of the computer in this system is particularly important because modifications are continually being made in the computer programs. Thus one must have confidence that programs work, both by themselves and in interaction with the other programs.

Reliability techniques.—Lack of knowledge regarding the probabilistic behavior of many business components makes it, at least for the time being, impossible to obtain a numerical measure of business system reliability. Thus one is forced to use the general probabilistic concepts as a guide but without attempting to obtain numerical measures. In this view, one might attempt to obtain parallel structuring whenever it is technologically and economically feasible.

The reliability of programs becomes of primary concern since no program can ever really be considered to be debugged. A program is, in the general usage of the term, debugged when the program error rate falls below some predetermined (and often unstated) level. This does not mean that all possible sources of difficulty have been eliminated. It is important that one be able both to detect errors in individual programs and to recapture data and program conditions lost as a result of the errors.

Memory protect devices may be used to prevent programs from going outside of predetermined bounds and hence injuring other programs. An illustration of such a device is found in the IBM System 360. In
In this chapter there has been a presentation of the concept of real-time systems. This has been presented because real-timeness is one of the more pressing characteristics that will be possessed by the postulated system and because systems possessing this characteristic are significantly different than those which lack it.

While there is conceptually no such thing as a nonreal-time system since all processing must be performed subject to some time limitations,
In the current usage, the term is used to refer to data-processing where little or no batching takes place, where there is little or no lag between the occurrence of events and the processing of related data, and where the computer is used to control a physical process. Hence in this usage, the term real-time implies the existence of severe time restrictions on the processing of data.

The need to meet severe time restrictions often requires the use of a sizeable computer, the existence of which facilitates the expansion of the scope of the overall processing capability. Expansion of this kind does not come without corresponding increases in complexity and, eventually, dependence upon the central processing system.

This chapter has not been a complete guide to real-time processing. Instead, it served to introduce the reader, who already possesses some familiarity with data-processing techniques and procedures, to the concepts and techniques that must be considered in this area. With this brief survey of where things are today, one can present an indication of where things might be tomorrow—the postulated system.
CHAPTER V

DATA PROCESSING CHARACTERISTICS OF THE POSTULATED SYSTEM

Management must have information as a basis for rational decisions. A management information system is a system designed to provide this information. The system must be able to provide it in a timely, reliable manner and to meet the needs of all possible managerial users. The objective of this chapter is to describe the data processing characteristics that such a system will possess. No attention will be paid here to specific hardware characteristics since these depend upon the current state of both computer technology and economic conditions.

The data processing characteristics of the management information system will be based upon the assumption that computers and human beings will each perform those functions for which they are best adapted. In general, computers excel in handling events characterized by a large volume of data or data manipulations. Human beings, on the other hand, have greater ability with events that occur infrequently, particularly where there is a pattern recognition problem related to the event. These characteristics are summarized in Table 5.

---

### TABLE 5

**FUNCTIONAL ADVANTAGES AND DISADVANTAGES OF MEN AND MACHINES**

| Data Sensing |  |
|--------------|  |
| **Man**      | **Machines** |
| Can monitor low-probability events for which, because of the number possible, automatic systems would not be feasible. | Program complexity and alternatives limited so that unexpected events cannot be adequately handled. |
| Under favorable conditions absolute thresholds of sensitivity in various modes are very low. | Generally not as low as human thresholds. |
| Can detect masked signals effectively in an overlapping noise spectrum on displays such as radar and sonar. | May not be useful when noise spectra overlap detection of signal. |
| Able to acquire and report information incidental to primary activity. | Discovery and selection of incidental intelligence not feasible in present designs. |

| Data Processing |  |
|-----------------|  |
| **Man**         | **Machines** |
| Able to recognize and use the information, redundancy (pattern) of the real world to simplify complex situations, e.g. recognition of airport through stages of ground contact, approach, and landing. | Little or no perceptual constancy or ability to recognize similarity of pattern either in spatial or temporal domain. |
| Reasonable reliability in which the same purpose can be accomplished by different approach (corrolary of reprogramming ability.) | May have high reliability at increased cost and complexity. Particularly reliable for routine repetitive functioning. |
### TABLE 5 (contd.)

<table>
<thead>
<tr>
<th>Man</th>
<th>Machines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Can make inductive decisions in situations not previously encountered; can generalize from the particular.</td>
<td>Virtually no capacity for creative or inductive functions.</td>
</tr>
<tr>
<td>Computation is weak and relatively inaccurate; optimal theory of games strategy cannot be routinely expected.</td>
<td>Can be programmed to use optimum strategy for high-probability situations.</td>
</tr>
<tr>
<td>Channel capacity limited to relatively small information throughput rates.</td>
<td>Channel capacity can be made as large as necessary for task.</td>
</tr>
<tr>
<td>Can handle variety of transient overloads and some permanent overloads without disruption.</td>
<td>Transient and permanent overloads may lead to disruption of system.</td>
</tr>
<tr>
<td>Short-term memory relatively poor.</td>
<td>Short-term memory and access times excellent.</td>
</tr>
</tbody>
</table>

#### Data Transmitting

<table>
<thead>
<tr>
<th>Man</th>
<th>Machines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Can tolerate only relatively low imposed forces and generate relatively low forces for short time periods.</td>
<td>Can withstand very large forces and generate them for prolonged periods.</td>
</tr>
<tr>
<td>Generally not good at tracking though may be satisfactory where situation requires frequent reprogramming; can change to meet situation; it is best at position tracking with changes under 5 radians per second.</td>
<td>Good tracking characteristics may be obtained over limited set of requirements.</td>
</tr>
<tr>
<td>Performance may deteriorate with time; usually recovers with rest.</td>
<td>Behavior decrement relatively small with time; wear maintenance and product quality control necessary.</td>
</tr>
<tr>
<td>Man</td>
<td>Machines</td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>-----------------------------------------------------------</td>
</tr>
<tr>
<td>Relatively high response latency.</td>
<td>Arbitrarily low response latencies possible.</td>
</tr>
</tbody>
</table>

**Economic Properties**

<table>
<thead>
<tr>
<th>Man</th>
<th>Machines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relatively inexpensive for available complexity and in good supply; must be trained.</td>
<td>Complexity and supply limited by cost and time; performance built in.</td>
</tr>
<tr>
<td>Light in weight and small in size for function achieved; low power requirement, less than 100 watts.</td>
<td>Equivalent complexity and function would require radically heavier components and enormous power and cooling resources.</td>
</tr>
<tr>
<td>Easy to maintain with a minimum of &quot;in task&quot; extras.</td>
<td>Maintenance problem becomes disproportionately serious as complexity increases.</td>
</tr>
<tr>
<td>Nonexpendable and interested in personal survival; emotional.</td>
<td>Expendable and unconscious of personal existence; will perform without distraction from problems arising outside of task.</td>
</tr>
</tbody>
</table>


Several ordinarily important factors will be ignored in this analysis. In particular it will be necessary to avoid consideration of economic or technological factors in order to deviate from the current state both of technology and the data-processing art. Otherwise the
system would be at best a technologically workable ideal. Similarly, no recognition will be taken of specific regulatory agency record-keeping requirements. These requirements are established in light of current data processing techniques. In the event that the regulatory agencies can meet their needs without requiring adherence to the currently specified rules, these rules may be altered.

The existence and scope of the system are closely related to the existence of computers able to perform logical manipulations of symbols; that is, computers which can perform arithmetic procedures and make decisions. Computer decision-making is beyond the scope of this analysis. It cannot, however, be completely ignored since it affects the nature and extent of human decision-making and determines the information requirements of the system.

The assumptions regarding economic and technological feasibility make it impossible to describe the detailed technical specifications of the system. However, it is possible to describe, in a general fashion, the data processing characteristics that must be present for the system to meet the requirements that have been established for the postulated system. A possible computer organization within the system is shown in Figure 7. (The reader should refer to Chapter IV for a discussion of items shown in this configuration). Alternative computer configurations may meet the needs of the system equally well. Nevertheless, this illustration may be used as a reference pertinent to the following sections.
Figure 7.--A Postulated Management Information System
An analysis of the input and output characteristics of the system must depend upon two factors: (1) the sources of the raw data and (2) the nature of the decisions made by human beings. The sources of the raw data are important since they determine both the characteristics that must be possessed by the data sensors and the degree of reliability that may be expected. The types of decisions made by human beings will determine both the information requirements of the system and the means for presenting this information.

**Input**

The information requirements must be discussed in broad generalities since specific information requirements are determined by the detailed characteristics of the decisions that are being made. Nevertheless, it is possible to utilize common characteristics of managerial decisions to specify the classes of information requirements.

**Sources.**—Management must have three classes of information: (1) information regarding general business conditions, (2) information regarding the structure of the firm and its environment, and (3) information regarding available resources. The examples of information needed by management presented in Table 6, are dependent upon the managerial functions specified in Chapter III. The purpose of this table is to illustrate the varied nature of this data.

The data necessary to meet these managerial needs originates from varying sources, some inside of the firm and some outside. For example,
TABLE 6
EXAMPLES OF INFORMATION NEEDED BY MANAGEMENT

General Business Data
Present and expected goals
Current position of the firm
   By itself
   In relation to the industry
Current performance

Structural Data
Structure of the market
   Sources of materials and information
   Outlets of finished products
Nature of the processes
   Raw materials and resources
   Types of operations being performed
      together with the interrelationships
      between the operations

Business Resources and Organization
   Facilities
   Finance
   Raw Materials
   Personnel

data regarding the goals of the firm and the specific procedures that are being followed in the firm can be obtained only by introspection. At the same time one must look outside of the firm for data regarding market conditions or actions of competitors. A summary of selected data sources is shown in Table 7.

This data is, and will continue to be, available to some extent in all businesses. There is, however, a difference in the methods used by various firms for obtaining and storing the data. To the extent that the data will enter the firm in a disorganized manner and will be maintained outside of the formal communications channels, it may be unavailable for future use. In these cases, the availability and quality of the information would depend upon where the data is being
TABLE 7

SELECTED SOURCES OF BUSINESS DATA

Data Originating From Sources Outside of the Firm

Traditional financial data
- Sales
- Purchases
- Collections
- Payments
- Obligations

Environmental data
- Actions of competitors
- Market structure and conditions
- General economic conditions

Data Originating From Sources Within the Firm

Traditional financial data
- Authorizations
- Receipts
- Cost accumulations
- Facilities and resource movements
- Directives
- General communications

Environmental data
- Goals
- Process and procedures changes

It should be observed, again, that the ability to discuss specific data sources and types is nonexistent since this is a function of the managerial needs in any given case. It will, however, be necessary to reckon with the need for specifics in the design of a particular system since provision must be made for the collection of data while the data is available. Failure to make such a provision means that the data will be unavailable for use in managerial decisions since the data will either have gone out of existence or the information
retrieval problem will be of a magnitude that is inconsistent with the
time requirements of the decisions.

Reliability factors.--The methods that are to be used to get
data into the management information system should minimize the
possibility of incorrectly received data. Although applicable to all
information systems, this requirement gains added importance as the
information system grows in scope and is adapted to computer processing.
There are two reasons that there will be an increased emphasis on data
accuracy. First of all, the use of computers for information system
purposes will be paralleled by a shift of decision-making to the
computer. To the extent that this takes place, the sensitivity of
the firm to erroneous information increases since the decisions will
be made by exacting operations research models (to be developed by
the individual firms) in which decision rules will be stated explicitly.
Secondly, management must have, and will continue to require, confi­
dence in the information that it uses for decision purposes.
Sensitivity to data reliability will also increase as more firms begin
to use computers, since the major decisions, made by management at all
levels, will affect the operation of the firm more rapidly than those
made by using a totally manual system. A management decision is
equivalent to an alternation of a parameter in the model of the firm.

2For an extensive discussion regarding computer decision­
making in current business practice, see M. H. Gross, "Standard Oil
This alteration will take place, to all intents and purposes, the instant after the decision is made.

The possibility of getting accurate input data into the system depends on the sensing device characteristics and the interaction between the human operator and the input devices. There are two classes of input: data which may be sensed as a by-product of natural business operations and data which must first be interpreted by human beings. Data which is sensed as a by-product of natural operations will be obtained by making the data source part of the information system. For example, the system may be connected to automated inspection stations, to the stockmarket ticker, or even to a thermometer measuring the outside temperature. The determination of relevant data sources must, of course, be made in the context of the operations of the firm. In each of these cases, the important characteristic is the direct sensing of the data by the mechanical device. Accurate sensing will depend solely upon the operation of these devices.

A large amount of data needed by the business firm is not available directly, instead, it must first be sensed by humans. For example, one of the most important operations performed by human beings is pattern recognition.\(^3\) This operation involves sensing data where there is considerable variance in form and content, e.g., human conversation. In this example there is considerable difference in the form of the data (content, regional and national accents), and the

\(^3\)Herbert A. Simon and Allen Newell, p. 48.
pertinent data must be isolated from irrelevancies. The second situation is identical to the first with the exception of the added step requiring human action. Reliability of data entering the system in this manner will depend upon the original sensing of the data by personnel of the firm and conversion of the data into machine-sensible form.

Reliability of data is classified according to validity and accuracy. Validity refers to the logical relationship between the data and the methodology of the problem solving process. Accuracy refers only to the specific numerical value assigned to the data. These are not independent characteristics. Data which is valid may be acceptable for use with a problem even though some inaccuracy exists. However, as accuracy of the data decreases, a point is reached where it is no longer possible to differentiate between inaccuracy and invalidity—the data is so inaccurate that it is invalid.

It will not be possible to make an a priori determination of data accuracy and validity because both of these characteristics are defined in terms of interrelationships between the data and the problem being processed. Where data is inserted by personnel of the firm, there will be a limited ability to evaluate accuracy by providing a visual record of the transaction which must be acknowledged by the employee prior to his finally entering the data in the system. Even in this instance, the input devices alone will be unable to differentiate between various types of data.

There must be an initial implicit assumption that the input devices are operating satisfactorily. The devices themselves cannot
be used as a check on their proper operation. Assume for example that
the device is malfunctioning. What assurance is there that the
malfunctioning device will properly diagnose and disclose its
failure? Assurance regarding reliability will have to be derived
from the interrelationships existing between the input devices and the
remaining components of the system.

The controls necessary to establish reliability are closely
related to the general evaluation of internal controls, and they are
discussed in that context in Chapter X. The sections dealing with
reliability factors serve only to mention the various considerations
necessary for adequate operation of the management information system.

Output

Users.—The end products of the information system will be
used by many different people. These users will vary in the types
of data that they require, but they will have in common the fact that
once they have the information they must use it as the basis for a
decision. In each case they will have to obtain data, assume that it
is accurate, and then use it. The output to be received by each of
these users differs in both form and content. At the one extreme
are completed financial statements or trend graphs; at the other extreme,
the raw data that will be rejected from the system because of its
extraordinary nature. In each case the data that is provided by the
system will meet the needs of the users exactly. No subsequent
calculations or manipulations should be necessary before it is used.
Reliability factors.—The considerations relating to the reliability of information and output units are identical to those discussed with respect to input data and devices. Again, it will not be possible to evaluate reliability apart from program interrelationships.

Data Transmission

Scope and nature

The area of data transmission includes all communications between the input or output devices and the central computer. It may also be taken to include transmission between a central computer and some subsidiary computer.

Reliability factors

There will be two possible errors relating directly to data transmission: (1) data that is incorrectly received from the sensing devices or computers and (2) data that is correctly received but incorrectly transmitted. In both of these cases the errors must be detected either by relationships that must exist within the system or by use of the computational abilities of the system. Discussion is deferred until the following chapter.

Data Manipulation

All operations necessary for the operation of the system that have not been included in the previous sections fall under the general classification of data manipulation. Included are such items as computation, data changes and decision-making. Some of the
operations discussed in this section are performed by the input
devices, output devices or data transmission facilities. These are,
however, processing operations that have been delegated because of
some added ability built into the other devices.

Reliability factors
The data manipulation facilities will have to assure that no data
is lost and that the correct program is being used, i.e., that the
monitor has selected the proper programs associated with the problem
being processed. It will also have to possess the capability of
determining whether all of the input or output units and data trans-
mission facilities are both available and in proper working condition.

The controls necessary to accomplish the required degree of
reliability fall most closely within the area of internal control
evaluation. They are discussed in the next chapter.

Summary
Two important conclusions may be derived from this chapter.
Evaluation of the management information system is not possible with-
out consideration of the decision-making capabilities of computers,
because these capabilities partially determine the information needs
of management. Secondly, it is not possible to isolate the individual
functions of the system—input and output, data transmission and
data manipulation—to obtain a measure of performance for that func-
tion alone. Instead, reliability of each function must be determined
within the context of the system as a whole—considering all existing
interrelationships.
CHAPTER VI

EFFECT OF POSTULATED SYSTEM ON INTERNAL CONTROLS

The purpose of this chapter is to consider the effect of the postulated system upon the internal controls of the firm.\(^1\) This evaluation precedes a discussion of the specific auditing techniques that must be used by the auditor because the evaluation of internal controls provides the auditor with both an overall view of the firm's operations and a basis for making an initial assumption regarding the reliability of the firm's representations.

Where internal controls are found to be satisfactory, the auditor has reason to believe that the records as a whole are reliable. He therefore restricts the extent of the tests used for evaluating the financial statement representations. An expansion of these tests may be necessary where subsequent events indicate that the initial assumption was invalid.

On the other hand, where internal controls are found to be unsatisfactory, no conclusion may be reached regarding the adequacy of the accounting records. It is possible that a small business, such

\(^1\)"Internal control comprises the plan of organization and all of the co-ordinate 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." Committee on Auditing Procedure, p. 27.
as a retail store may have satisfactory records even in the absence of controls as comprehensive as those found in a multi-department firm. In any event, the absence of these controls is an indication to the auditor of the necessity for more extensive testing than would be required in the presence of the controls. Extension of testing may mean an increase in the size of the sample or possibly the use of supplementary tests.  

Classification.--The general classification internal control may be subdivided into two subclasses—accounting controls and administrative controls. The AICPA differentiates between the two classifications as follows:

Accounting controls comprise the plan of organization and all methods and procedures that are concerned mainly with, and relate directly to the financial records. They generally include such controls as the system of authorization and approval, separation of duties concerned with record keeping and accounting reports from those concerned.

2 Note for example, that Stettler states: "retail store sales volume can be judged from the amount of customer traffic in the store, and confirmed when the cash registers are cleared at the end of the day." Howard F. Stettler, Auditing Principles (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1961), p. 56.

3 This is not the only possible way to subdivide internal controls. For example, Lenhart and Defliese subdivide accounting controls into internal accounting controls ("Internal accounting control . . . is by definition designed in the absence of dishonesty on the part of those who operate and administer it, to promote the accurate and suitable recording and summarizing of authorized financial transactions."), and internal check (". . . an adjunct to internal accounting control and is designed to supplement the latter by furnishing a means to safeguard assets against manipulation of dishonest employees concerned with the accounting function of the business"), Lenhart and Defliese, pp. 59-60.
with operations or asset custody, physical controls over assets, and internal auditing.

Administrative controls comprise the plan of organization and all methods and procedures that are concerned mainly with operational efficiency and adherence to managerial policies and usually relate only indirectly to the financial records. They generally include such controls as statistical analyses, time and motion studies, performance reports, employee training programs, and quality control.

Many accounting controls and administrative controls overlap, e.g., the plan of organization is listed by the AICPA as both an accounting control and an administrative control. It is necessary to differentiate between accounting and administrative controls. The criterion set up by the AICPA requires that one determine the degree of relationship existing between the control being classified and the financial records. Degree of relationship depends, however, upon the perspective of the person making the classification and upon the situation in a particular firm. Therefore the criterion has been modified for application in this analysis. The following rules are followed:

1. Where there is, in the opinion of this writer, a clear and direct relationship between the control and the financial records of the firm, the control is classified as an accounting control.

2. In all other cases the classification is on the basis of convenience.

\[4\text{Committee on Auditing Procedure, p. 28.}\]
Administrative Controls

The independent auditor does not usually evaluate administrative controls as such, but he does not ignore them completely since they are closely related to the accounting controls. Without the administrative controls, it is doubtful whether the accounting controls could exist or be utilized. For example, the existence of employee training programs gives the auditor an indication of the quality of the personnel, and this in turn is an indication of the reliability of the records. In addition, the administrative controls support the results of other auditing procedures. Stettler says that

... there may be occasions, ... when some aspect of administrative control may prove useful to the auditor in establishing the reliability of the financial records, and in such instances the auditor should, of course, make an evaluation. For example, a company's shipping department might maintain teenage statistics as a guide for staffing the department and in controlling the productivity of its workers. The auditor might find these statistics useful as further support of the company's sales and outgoing transportation figures.6

The existence of satisfactory administrative controls is a strong indication that the overall performance of the firm is satisfactory.

Scope

The purpose of this section is to discuss several administrative controls—the plan of organization, the adequacy of personnel, the formal plans and procedures, and the existence of an internal auditing department—and to illustrate their natures and the way that

5Lenhart and Defliese, p. 58.
6Stettler, p. 60.
the auditor utilizes them. This is not a definitive list of administrative controls; they were chosen because they illustrate the process. This analysis takes place in two distinct steps: (1) the section that follows contains a brief description of each of the controls together with a short statement regarding the ways in which the auditor uses the controls; (2) after the controls have been presented, the effects of the postulated system will be discussed.

Plan of organization.—The plan of organization is a statement of the interrelationships existing between various segments of the firm. It generally takes the form of an organization chart which is "a graphic... presentation of certain information concerning functions, functional groupings, and lines of responsibility, authority, and accountability in the organization."  

There is no need for an organization chart in a small one-man business because the owner-operator needs to control only his own actions. However, as the size of a business increases, organizational separation of the management functions is almost inevitable. The direct cause of this separation is complexity; it becomes increasingly difficult for a single centralized manager not only to absorb all of the data affecting the firm but also to make all necessary decisions. This difficulty arises because of the volume of data that must be processed and because of the resulting gap between the occurrence of events and the eventual sensing of the events by the decision-maker.

7Davis, p. 119.
One method for eliminating, or at least minimizing, the problems of centralization is decentralization, i.e., dividing work among several people. The decentralized organization acts as a filtration device; data flows up toward the higher echelons of management, becoming increasingly summarized as it nears the upper levels of management. The reverse process takes place with respect to decisions; delegation of authority results in a filtration down from the top; i.e., decisions become increasingly detailed as they reach the lower echelons of the firm.

The decentralization process carries with it several problems. In order to solve the timeliness problem, the responsibility and authority for some decisions are delegated. This in turn, makes it increasingly difficult to coordinate the firm as a whole. Because decentralization usually takes place along specialized lines, e.g., accounting, sales, or production, these specialized functions are not as separate as they might appear. Actions taken in any one function generally affect the others.

The existence of a formal plan of organization is important to the auditor. Because it is a formal statement of interrelationships and responsibilities, it provides a basis for determining the extent to which actions taken in one part of the firm may be used as a control on the actions taken in another part of the firm. This is possible because the separate functions are logically interrelated,
Adequacy of personnel.--The auditor does not evaluate the skill possessed by each employee. Instead, he relies upon the existence of and adherence to a stated personnel policy. In this respect, he evaluates both the hiring and promotion policies of the firm.

Successful use of a plan of organization depends upon the existence of personnel qualified for the positions which they occupy. Employees possessing adequate skill, training, and ability are necessary for the delegation of authority and its attendant responsibilities. Inadequately skilled employees cannot be expected to perform adequately. On the other hand, employees with skills that far exceed the needs of their positions present a potential danger to the firm. Because they are often able to complete their assigned tasks with little effort, they have excess capacity which may or may not be put to use in the best interests of the firm.

Formal plans and procedures.--This control includes an evaluation of the existence of job descriptions, procedures manuals, written statements of firm policy, and such goal-oriented control mechanisms as budgets, all of which supplement the plan of organization. The existence and ready availability of these documents is extremely beneficial to both the firm and its auditor. For example, an explicit statement of authority and responsibility reduces the possibility of inadvertent errors due to communications difficulties. At the same time the existence of formal plans and procedures is an aid to morale, which in turn tends to reduce the propensity to err.
Existence of an internal auditing department.—The expansion of business adds complexity to the process of control. It is therefore natural to expect management to set up one department whose sole responsibility is obtaining an overall view of the existing controls in the firm to assure adherence to managerial policies.

The internal auditing department performs this function and is an independent appraiser of the firm's activities. Its purpose is to furnish management with information regarding the performance of the various segments of the firm, thereby aiding management in the discharge of its responsibilities. One of the primary methods used to meet this objective is the measuring of the extent and effectiveness of the controls in the business. Among the specific activities performed by the internal auditor are:

1. Reviewing and appraising the existence and applicability of controls. Controls in this sense are not limited to financial controls.

2. Determining the extent of compliance with company policies, plans and procedures.

3. Determining whether company assets are properly safeguarded.

4. Evaluating the reliability of data developed within the organization.

5. Evaluating performance related to assigned responsibilities.

Internal auditing is nominally a staff function. Once the internal auditor has reviewed the operation of a segment of the firm, he can not take action, for he has no authority over the people whose work he reviews. A summary statement regarding the responsibilities and
activities of the internal auditor, as stated by the Institute of Internal Auditors, is found in Table 8.

The existence of an internal auditing department is not a substitute for an independent audit. The internal and independent auditors differ in two important characteristics—scope of operations and orientation. The independent auditor is an independent contractor retained by the business firm in order to add confidence to its financial statement representations. He does this by associating his professional standing with the financial statements of the firm. The primary orientation of the independent auditor is toward the protection of third parties who make use of the financial statements.

On the other hand, the internal auditor is retained by the business firm, as an employee, to aid management in controlling the firm. This is accomplished by continually analyzing the operations of the various controls of the business. Reliability of performance of the internal audit department is not derived specifically from the existence of the department and its employees. In the absence of indications to the contrary, it is assumed that the internal audit is satisfactory. While the objectives stated in Table 8 place emphasis upon many of the financial aspects of the business, the literature of the Institute does not indicate that this is the case in practice; the primary orientation of the internal auditor is in the area of administrative controls although he does not ignore the financial controls.
TABLE 8
STATEMENT OF RESPONSIBILITIES OF THE INTERNAL AUDITOR

**Nature of Internal Auditing**

Internal auditing is an independent appraisal activity within an organization for the review of accounting, financial, and other operations as a basis for service to management. It is a managerial control which functions by measuring and evaluating the effectiveness of other controls.

**Objective and Scope of Internal Auditing**

The overall objective of internal auditing is to assist all members of management in the effective discharge of their responsibilities by furnishing them with objective analyses, appraisals, recommendations and pertinent comments concerning the activities reviewed. The internal auditor, therefore, should be concerned with any phases of business activity wherein he can be of service to management. The attainment of this overall objective of service to management should involve such activities as:

- Reviewing and appraising the soundness, adequacy, and application of accounting, financial, and operating controls.

- Ascertaining the extent of compliance with established policies, plans, and procedures.

- Ascertaining the extent to which company assets are accounted for and safeguarded from losses of all kinds.

- Ascertaining the reliability of accounting and other data developed within the organization.

- Appraising the quality of performance in carrying out assigned responsibilities.

**Authority and Responsibility**

Internal auditing is a staff function rather than a line function. Therefore the internal auditor does not exercise direct authority over other persons in the organization whose work he reviews.

The internal auditor should be free to review and appraise policies, plans, procedures, and records; but his review and appraisal does not in any way relieve other persons in the organization of the responsibilities assigned to them.
TABLE 8—Continued

Independence

Independence is essential to the effectiveness of the internal auditing program. This independence has two major aspects.

(1) The organizational status of the internal auditor and the support accorded to him by management are major determinants of the range and value of the services which management will obtain from the internal auditing function. The head of the internal auditing department, therefore, should be responsible to an officer of sufficient rank in the organization as will assure a broad scope of activities, and adequate consideration of, and effective action on the findings or recommendations made by him.

(2) Since complete objectivity is essential to the audit function, internal auditors should not develop and install procedures, prepare records, or be engaged in any other activity which they normally would be expected to review and appraise.

This statement was approved by the Board of Directors of THE INSTITUTE OF INTERNAL AUDITORS at a meeting in Los Angeles on May 30, 1957.

The independent auditor has a primary interest in the financial aspects of business operations. He concentrates on those items which provide him with evidence regarding the validity of the financial statement representations. Evaluation of other aspects of the business is secondary and usually limited to those items which may supplement the accounting controls. 8 A summary of these comparisons is found in Table 9.

The existence of an internal auditing department is important to the independent auditor. Because the internal audit department

8 This has changed to some degree in recent years. Many independent auditing firms now maintain management services departments.
## TABLE 9

INTERNAL AUDITING AND INDEPENDENT AUDITING CONTRASTED*

<table>
<thead>
<tr>
<th>Internal Auditing</th>
<th>Independent Auditing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Audit is performed by a company employee.</td>
<td>Audit is performed by a professional practitioner who is engaged as an independent contractor.</td>
</tr>
<tr>
<td>Primary concern is in serving the needs of management.</td>
<td>Primary concern is in fulfilling the needs of third parties for reliable financial data.</td>
</tr>
<tr>
<td>Review of operations and internal control is made primarily to develop improvements and induce compliance with established policies and procedures; not limited to financial matters.</td>
<td>Review of operations and internal control is made primarily to determine scope of examination and reliability of financial data.</td>
</tr>
<tr>
<td>Work is subdivided primarily according to operating functions and lines of management responsibility.</td>
<td>Work is subdivided primarily in relation to principal balance sheet and income statement accounts.</td>
</tr>
<tr>
<td>Auditor is directly concerned with the detection and prevention of fraud.</td>
<td>Auditor is incidentally concerned with the detection and prevention of fraud, except as financial statements may be materially affected.</td>
</tr>
<tr>
<td>Auditor should be independent of treasurer and chief accountant, but subservient to needs and desires of other elements of management.</td>
<td>Auditor should be independent of management both in fact and in mental attitude.</td>
</tr>
<tr>
<td>Review of company activities is continuous.</td>
<td>Examination of supporting data to financial statements is periodic—usually once a year.</td>
</tr>
</tbody>
</table>

*Stettler, pp. 56-57.*
performs many of the same duties as the independent auditor, an
evaluation of the scope of the department and its findings should
indicate to the independent auditor: (1) the scope of the existing
controls and (2) the extent to which these controls are operating
satisfactorily. The existence of an internal auditing department is
also an indication of the overall attitude of management toward the
successful operation of the firm.

**Effect of the postulated system upon administrative controls**

In the previous section a brief description of several adminis-
trative controls was presented. In this section an examination is made
of the effects of the postulated system upon these controls. The
examination recognizes that administrative conditions represent a point
on a continuum of changes that began with the introduction of punched
card processing. For this reason, the analysis traces the progressive
changes from manual processing, through the introduction of punched card
processing, electronic computers, and finally to the postulated system.

**Plan of organization**

The effect of the postulated system on the plan of organization
may be considered in two segments: the effect on the trend toward
decentralization. and the effect on middle management. In both
segments there is an indication that current trends will be reversed,
i.e., there will be a tendency for business to re-centralize and a
tendency toward elimination, or at least simplification, of the job
of middle management.
Centralization.—Organizational decentralization of business took place as a result of the increased volume of data and the complexity of business decisions. It provided a means for filtering the data flow to the upper echelons of management and, at the same time, it created an added managerial problem of coordinating a decentralized operation. Communications within the firm became increasingly complex because of this need for coordination.

The introduction of punched-card processing equipment provided the ability to use the same basic document in different contexts. For example, a card representing a single sale might, at various times, be part of a sales summary, an analysis of salesmen's performance, or of an account receivable detail. To use the punched-card in a different context, it was only necessary to re-sort the cards. With one exception, the much heralded punched-card did not result in any large scale changes within the firm. The exception to this statement is firms where manual data processing systems have grown in an unorganized fashion. In this case it was discovered that the installation of a punched-card processing system required a preliminary, full scale systems analysis to determine the sources of data and the flow of information. In many of these cases, the preliminary analysis eliminated a sufficient number of clerical inefficiencies to make the punched-card system unnecessary.

In other situations, the advent of punched-card processing did not have a substantial effect on the firm. The punched-card equipment was usually introduced to the firm in the Controller's Department for two reasons: (1) the earlier equipment could only add, subtract, sort,
and list the contents of cards; and (2) the Controller's Department contained the highest visible volume of this type of operation to be processed. In this application it was used to prepare substantially the same analyses that were prepared with manual systems. There were three benefits derived from the introduction of punched-card equipment: (1) efficiencies resulted from the preliminary data survey; (2) clerical savings were made; and (3) timeliness of information increased.

There were indications that punched-card processing would result in a reversal of the trend toward decentralization. Three factors acted as pressures for recentralization: (1) the place where the equipment originally entered the firm, (2) the initial investment in equipment and (3) the needed training of personnel. As stated earlier, punched-card processing was first applied to the processing of accounting data. The Controller's Department therefore had an investment in the machines and the personnel to operate them. As technology advanced it gradually became possible to perform arithmetic operations other than addition and subtraction which, in turn, made possible increased machine utilization by processing non-accounting problems. To the extent that other departments were unable to rationalize possession of their own equipment, the Controller's Department became a general purpose service bureau, processing both its own problems and those obtained from the other departments.

The use of the Controller's Department as a service bureau was not without departmental conflicts. These conflicts arose for two reasons: lack of independence of the department and nature of the problems being processed. Accounting problems are characterized
by a large volume of data and very noticeable time constraints. Failure to meet time constraints is readily noticeable, e.g., the obvious difficulties associated with a missed payroll deadline. For these reasons a frequently heard comment concerned the discontinuance of processing non-accounting problems to give precedence to accounting problems. Use of the Controller's Department for data-processing meant giving up part of the empire created in another department.

Computers differ from punched-card equipment in two major respects: the ability to use media other than punched-cards and the ability to use a program of stored operations. These differences resulted in increased speed, flexibility and capacity. The computer made it possible to execute an entire program at one time, permitting the program to handle sequencing of individual operations within the process.

The effect of computers upon the organizational structure of the firm depended upon the objectives set forth at the time of the initial installation. If the purpose of installing the computer was solely to enable faster processing of more data, then the net effect of the computer was similar to that experienced as a result of installing a punched-card system. The computer replaced much of the punched-card equipment in the Controller's Department but little else
changed. As the cost of computers dropped, they were acquired by other departments which used them as a supplement to manual data-processing methods.  

On the other hand, if management recognized that the power of the computer permitted them to obtain analyses that were previously unavailable, the results were different. In these situations, data-processing was assigned to a separate information processing department which acted as a service bureau to others. One example illustrating a firm where this approach was followed is The International Shoe Company. In this case the Controller's Department already possessed a punched-card processing system. The decision to acquire a computer was motivated by a desire to reduce costs through an integration of related functions in the firm. The computer was acquired in addition to the punched-card system with only the more sophisticated analyses being processed on the computer. Vogt states that the net effect of this approach has been a trend toward recentralization around the computer.  

Advances in computer capacity and data transmission capabilities have begun to shift the trend back toward centralization. The primary reason for this shift is an economic one; the newer, more powerful

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11 Ibid., p. 144.
computers are more costly in an absolute sense but less costly per operation performed. For this reason, maximum benefit from computers is obtained by using one, large, centrally located computer rather than several, less powerful, decentralized computers. Firms such as General Motors, which have always been used as examples of a decentralized managerial philosophy, are now recentralizing.\(^\text{12}\)

The trend toward recentralization is associated with a separation of the data-processing function from the Controller's Department. The pressures for separation are the high cost of the computer, and the growth in the power of computers and the programming skill needed for their usage. Increases in computational power are achieved at a cost. It becomes increasingly difficult for any one department to rationalize sole possession of the computer. At the same time the increased power of computers means that the proportionate share of computer time allocated to any one department is decreasing. No longer is the Controller's Department the major user of the computer; it is just one department among many.

With increases in power, the computer becomes more than simply a data-processor. To the extent that decision rules can be stated explicitly, they can be programmed for the computer to make decisions. This change has two major implications: (1) it requires increased programming skill because the programmer must understand both the decision rules and the art of programming and (2) it represents a major

\(^{12}\text{See Gilbert Burck, "Management Will Never Be The Same Again," Fortune, LXX (August, 1964), 125-126, 199-204.}\)
usurpation of authority because it takes away from the individual departments part of their reason for existence. Data-processing is no longer a staff function. It is now a hybrid, staff-line function which exercises direct control over some of the operations of the firm and at the same time provides advisory services that aid management in the performance of its functions.

The postulated system would represent an extreme of this trend. The system would be sufficiently large to provide any information needed by management. It would be the focal point of a centralized management because it could provide all of the information required for the operation of the firm. The comprehensiveness of the system would require that it be established as a separate department. As such it would be able to provide for and coordinate all of the information requirements of the firm. However, in order to adequately meet the needs of all managerial users, the department would have to be independent of controls established by any single department; e.g., it will not be feasible to have accounting processing take precedence over non-accounting processing since this is inconsistent with the requirement that the system meet all managerial needs.

A team approach to the solution of problems will be followed for three reasons: (1) the size of the individual problems will often be too large for a single programmer or analyst to handle. (2) integration and coordination of all items affected by the program requires knowledge of each of the program's effects. and (3) the varied problems that
must be handled require knowledge of many different aspects of the
firm's operations. ¹³

Middle Management.—When the switch was made from manual
processing to punched-cards, little thought was given to the possibility
that middle management might someday be affected, for the major impact
of this form of processing was thought to be in the clerical area.
However, with the advent of the computer and the current advances in
computational ability, this topic is receiving increased attention.
The main impact of punched-cards was in clerical savings; therefore,
the remaining areas of possible affect are in the realm of middle
management. The purpose of this section is to examine the possible
impact of the postulated system on middle management.

To investigate this topic one must first understand the nature
of the operations performed by people. These operations may be
divided into three classes: clerical tasks, programmed tasks and non-
programmed tasks. The classification of tasks depends solely upon
the knowledge required for their accomplishment, not upon any
fundamental association.

A "clerical task" is so completely analyzed that there is little
more than simple deductive logic involved in its performance. An
example of this classification is the preparation of a payroll. While
there are many alternatives which must be considered,—overtime, social
security deductions, withholding tax, special deductions—the logic

¹³ cf., p. 86.
involved when considering any one or group of these alternatives has been stated in detail beforehand. For example, determining whether a particular employee should get overtime pay requires answers to questions such as: Does this employee's pay group qualify for overtime? What is the "normal" work-day or work-week? Has this employee worked in excess of the normal? Because the logic in these tasks can be stated explicitly, it is possible to assign the tasks to computers.

The second type, a "programmed task," is well defined, relatively systematic and somewhat repetitive. Within this classification are such items as pattern recognition, information retrieval and programmed problem-solving. Pattern recognition involves the matching of sensory perceptions with previously established normative patterns. While this operation seems relatively uncomplicated, consider the difficulties that humans have communicating—a form of pattern recognition—when the parties involved come from different geographic locations. There have been many advances in this area of human knowledge, e.g., the ability to specify logically the system of perceiving the characteristics of the letters comprising the alphabet; however, similar success has not been achieved in other areas, such as oral communication.14

Closely related to the process of pattern recognition is the process of information retrieval which involves the selection of specific items of data from a large mass. It involves recognition of

14 Herbert A. Simon and Allan Newell, "What Have Computers to Do with Management?" Shultz and Whisler p. 48.
and differentiation between the characteristic of a given mass. While this task also seems simple, the opposite is true. Information retrieval involves the initial sensing of data, its coding, and its subsequent reacquisition at exactly the time it is needed. Each of these factors complicates the overall process. The initial sensing of data depends upon pattern recognition and is therefore subject to the limitations discussed in connection with that process. Retrieval of information is possible only if the information has been coded prior to its storage. This does not mean that any formal coding process need take place even though that is often the case. For example, correspondence is not formally coded but is filed by assumed pertinent characteristics, e.g., name of correspondent or data. The information retrieval is complicated by the large quantity of varied information potentially needed and the varied methods possible for coding any one item. Consider, for example, a related problem, that of coding parts in an inventory system. If a part is related to a government contract, it may be referred to by major assembly, vendor number (and if there are several vendors involved, by any one of their numbers), or government service classification. This problem is further complicated by the different ways in which any given code may be written.

The problems associated with pattern recognition have generally meant that information retrieval of infrequently needed items is best handled by humans. The obvious method for handling this problem in a

\[15\] In this sense coding is being used to refer to the process of assigning symbols as a means for identifying data.
computer--item by item search of memory--often cannot be used and still satisfy the time constraints of decisions, given the current state of technological achievement.

Some classes of problems are so simple that they may be solved using programmed problem solving. The logic they involve may be specified in detail but not to the extent necessary to classify them as clerical problems. Examples are reordering of merchandise, balancing production lines, or scheduling shipments. In each case the factors influencing the decision are assumed to be known. However, lack of confidence regarding the existing interrelationships often requires modification of the final decisions by humans.

The third type, an "unprogrammed task," is one which is not well defined, not necessarily repetitive and, therefore, not necessarily systematic. The decisions associated with the planning function of management are generally in this class. These decisions are hypothetical and generally involve the consideration of numerous factors, many unspecifiable. The nature of the decisions does not require them to be unstructured because this characteristic is dependent solely upon the current state of man's knowledge about his actions.

In view of the diversified nature of man's actions, it is not possible to make a definite statement regarding the effect of the postulated system upon middle management. The effect in a given firm depends largely upon how that firm has conceived the middle management function. Certainly, generalised statements may be made regarding the
effects of the postulated system. These comments result from the
decision-making capability of the system.

To the extent that middle management performs clerical operations,
its function will surely be taken over by the computer. The
remaining functions will be dependent upon the extent to which speci-
fiable knowledge exists regarding the decisions which they make.
While computers are unable to make any unprogrammed problem-solving
decisions, it will be possible for them to aid management. For
example, there is considerable research being performed in the area
of heuristic program solving. Using such methods, the process of
searching various alternatives is reduced, thus assuring consideration
of all alternatives consistent with the existing time constraints.

Effects on the auditor.—The changes in the plan of organization
that affect the independent auditor relate to (1) the auditor's
ability to determine the extent and effect of existing interrela-
tionships and (2) the extent to which actions in one part of the firm
may be used to validate actions taken elsewhere in the firm.

There is a definite indication that the trend toward
decentralization will be reversed. This is not unexpected because

15 This in itself does not imply a reduction in the quantity of
people occupying middle management positions.

16 If a program is guaranteed to lead ultimately to the problem
solution, it is called algorithmic; if not, it is called heuristic.
Thus, by heuristic, is meant any procedure used to reduce the
searching process of a problem-solving activity. Note that many of
the human activities fall into the classification of heuristics
rather than algorithmics.
the major pressure for decentralization was the complexity of manual
data-processing. The existence of a large, powerful computer as the
core of the postulated system implies the ability to process any
needed data. This ability combines with the need for thorough
coordination of information to create a strong pressure for centralized
processing of data.

The need for continuing control over the highly complex
interrelationships in the firm will tend to increase the auditor's
ability to (1) determine the existence of interrelationships and (2)
determine the effects of the interrelationships. This ability is
closely associated with the existence of formal plans and procedures.
It is therefore discussed as part of that topic.

The most critical concern of the auditor deals with the ability
to use the interrelationships that exist in a business as a basis for
controlling the accuracy of the firm's records. Recentralization by
itself seems to eliminate some of the independence that made the
results obtained in one department useful as a check on results
obtained elsewhere. Further investigation, however, indicates that
this will not be the case. A separate information processing
department may be set up which will remove all processing from the
control of the individual departments. While this means that a single
department will process records that are used as a basis for control,
one over the other, two additional factors must be considered. The
inclusion of all the records within one integrated system means that
logical interrelationships may be able to be used as a source of
constant control. This contrasts to the less automated systems where reconciliation with related records takes place only periodically, and then only if the interrelationships are known. The second factor to be considered is that separation can take place within a single information processing department. Only if there exists the ability to make either intentional alterations in the records or undetected unintentional errors would there be a lack of independence. It will be shown in the following section, which deals with "Personnel," that this ability would not in fact exist.

The changes in middle management that may be caused by the postulated system would have no effect upon the plan of organization as such. Instead, the change in the type of decisions made by middle management would imply increased confidence in the decisions made. Because both the decision-making and record keeping functions are part of one integrated system, there will be added assurance regarding the reliability of the records. In the postulated system there would, in effect, be no separation between these two functions. Therefore, modification of the records takes place as part of the decision-making process.

It may be concluded, then, that the trend toward centralization and the changes in middle management would not reduce the value of the plan of organization to the auditor. On the contrary, the organizational changes would give the auditor added assurance regarding the reliability of the firm's records. This added assurance is derived from the interrelatedness that is a necessary part of the system.
Personnel

The personnel of the firm may be divided into two segments for the purpose of evaluating personnel and personnel policies. These segments are determined by the proximity that the personnel bear to the postulated system. The two segments are (1) those employees of the firm whose primary function is external to the system proper and (2) those employees whose primary function requires work on the system.

In the first group, the group which includes employees who are indirectly related to the system, changes in the nature of their jobs will depend on the extent to which the computer is able to perform parts of the employee's job. It has already been shown that clerical operations are readily programmable, as are certain programmed decision-making tasks. This means that the tasks assigned to these employees consist of the remaining operations of pattern recognition and unstructured decision-making.

The objective of the auditor in evaluating personnel and personnel policies will not change, i.e., it remains an attempt to evaluate the performance of the business as a whole, especially concerning the reliability of the financial statement representations. The need for this evaluation in the postulated system will vary inversely with the extent to which the system 'monitors' the actions taken by these employees. Continual monitoring of these actions, e.g., the correct use of input/output devices and the logical consistency of their decisions with the firm's operations, will
take place. To this extent, an explicit evaluation of personnel practices need not be undertaken because a numerical performance measurement can be maintained by the system. The existence of a numerical performance measure would enable the auditor to obtain a more objective indication regarding this aspect of internal controls than is currently possible.

The employees who work on the postulated system, the second group, may be divided still further into two sub-groups: computer operators and programmers. These two groups are considered together in the analysis since there is no separation of their functions in older systems.

In the early days of punched-card and electronic data processing, an operator needed skills in both programming and the operation of equipment. It was also expected that the program would be run either by the person who originally programmed it or by someone else who was intimately familiar with its contents. The operator's console, on a computer, was designed in such a manner that the operator could constantly monitor the operation of the computer. This design facilitated error correction during the course of program operation--so called "console debugging." The operator could, and often did, make changes in the program during its execution. This lack of separation, understandably gave the auditor considerable reservations regarding the adequacy of internal controls.

The postulated system will no longer possess these capabilities. The monitor will take over the detailed procedures necessary when
monitoring operation of the program. This change will be necessitated by (1) the increased complexity of the programs and (2) the time-cost involved with manual console interference. The time constraints associated with computer processed programs will make it impossible for traffic direction within the system to be placed under human control. Human beings are too slow sensing difficulties and then reacting to them.

As increased knowledge is gained about the decision-making process, the complexity of the programs will increase to the point that considerable specialized knowledge will be required to understand the complex interrelationships contained in any program. For this reason there will be a separation of the programming and the operation of the system. The possibility for console debugging, and hence the need for a flexible operator's console, will no longer exist. Instead, errors will be sensed by the monitor, noted, and then returned to the programmer with a monitor directed diagnosis of the conditions existing at the time the error was sensed. The operator of the computer need not know the contents of the computer program being executed. If the operator has no knowledge of the program and cannot do console debugging, there is no reason why he need have any programming knowledge at all.

As in the case with employees whose jobs were only indirectly related to the system, the computer's ability to maintain performance reports may be applied to this group of employees. After the operator is given instructions, e.g., load a particular tape on a tape unit,
his successful completion of the assigned task may be tested by the computer program. Two actions follow this test. First, the system will either proceed if it senses satisfactory performance, or it will send a message requesting that corrective action be taken (with possibly a reprimand) in return for unsatisfactory performance. Secondly, the monitor will update a performance record of the operator’s actions.

**Effect on the auditor.**—The need for explicit evaluation of personnel and personnel policies decreases to the extent that the computer monitors the actions of the employees. The reason for this decrease is found in decreased freedom of action on the part of the employees. In addition, the availability of complete reports regarding the performance of many employees will permit the auditor to make judgments previously impossible in this area.

An exception to the above statements exists in the case of programming personnel because their actions cannot be monitored to the same degree as the other employees. In this case the vague nature of this control does not differ from that found in systems existing at the present. It will still be necessary to examine such items as hiring policy, promotion, job assignment practices, and so forth.

**Formal plans and procedures**

The conversion to punched-card processing and then to computer processing has increased the availability to the auditor of formal statements of procedure. This availability follows from the nature
of data-processing. Because electro-mechanical devices (punched-card equipment and computers) are only able to follow a prescribed set of instructions, details regarding the actions that they are to take must be specified in advance of the decision situation. This specification takes the form of either a wired electric circuit or a computer program. These devices cannot deviate from the prescribed specification.

To assure proper integration of the various system components, the postulated system will require maintenance of a central data file in addition to the programming detail specified above. This file will contain details regarding all existing interrelationships. For example, it will indicate for each datum its source and description, the programs that are affected, the types of changes that take place in each program, and the variables used to represent the data within each program.

**Effects on the auditor.**—The auditor examines the formal plans and procedures to determine the validity of those procedures relating to the financial statement representations. This evaluation by the auditor is valid only to the extent that the procedures examined are the procedures actually followed. Indeed, difficulties in the evaluation of a manual system arise due to either the lack of a statement of procedure or the difficulty associated with determining if the procedures are actually being followed.

The difficulties found in a manual system will largely be eliminated in the postulated system. There must be a formal statement of procedure in existence since the formal statement will be related
to the computer program without which the system cannot operate. At
the same time, adherence to the formal plan is assured for two
reasons: (1) the computer can only execute those instructions that
it has been given and it will execute them each and every time that
the need arises and (2) adherence of employees to specified procedures
is assured, or at least aided, by constant computer monitoring of their
actions. In short, the auditor will be able to achieve a greater
degree of assurance regarding adherence to formal plans in the
postulated system than is currently possible.

Internal auditing

The effects of the postulated system on the internal and
independent auditors are similar. To the extent that controls have
been established within the computer programs, evaluation of the
program is both an evaluation of the control and an assurance that it
is being faithfully utilized. An examination of the program should
also indicate whether established policies, plans, and procedures are
being followed.

Using the functions of internal auditing listed on pages 117 and
118 as a reference, one can see that an initial review of the postulated
system, together with control over changes that are made, should
satisfy the first two objectives of the internal auditing department,
namely:

1. Reviewing and appraising the existence and applicability
   of controls.
2. Determining the extent of compliance with company policies, plans and procedures.

Emphasis within the department will therefore be placed on the remaining functions.

3. Determining whether company assets are properly safeguarded.

4. Evaluating the reliability of data developed within the organization.

5. Evaluating performance related to assigned responsibilities.

This shift in emphasis brings closer the areas of interest of the internal and independent auditors.

No specific mention of the internal auditor will be made in the discussion of accounting controls. It should be noted, however, that both the internal and the independent auditor will benefit considerably in their ability to evaluate the reliability of data (the fourth objective of internal auditing). Therefore, both will concentrate upon the remaining two objectives, differing only in perspective—the internal auditor is interested in protecting the firm's interests and the independent auditor is interested in the representations made to outsiders.

The overlap suggests that the independent auditor may be able to place more reliance on the work of the internal audit department. If there is sufficient effort in safeguarding company assets, there is assurance that the assets still exist in the company. This does not mean that the independent auditor will be replaced in his function by the internal auditor. The reasons for this assertion are:
1. The nature of the independent audit requires that confidence be added to financial statement representations by associating the professional reputation of the auditor with these representations. One important characteristic of professionalism not possessed by the internal auditor, independence from the firm making the representations, is sufficiently strong to eliminate him from playing a role similar to the independent auditor.

2. The interests of the internal auditor with respect to assets stop after his determining that assets are properly safeguarded. On the other hand, the external auditor's interests extend beyond consideration of the assets existence to valuation and classification on the financial statements.

Accounting Controls

The independent auditor recognizes the importance of the existence or nonexistence of internal accounting controls. These controls relate directly to the safeguarding of assets and the reliability of the financial records. More than any other controls, the internal accounting controls establish the extent of the specific tests required in order to gain the proper degree of assurance in financial statement representations.

Internal accounting controls include all of the procedures that are concerned primarily with the financial records. This analysis of internal accounting controls is restricted to data-processing controls, i.e., those controls having as their primary objective assuring the
accuracy of financial statement representations. By so restricting the analysis of internal accounting controls, no consideration is given to those controls which have closely related objectives such as safeguarding assets.

Description of the controls

The data-processing controls include efforts made to control the use and processing of documents, and the accuracy of computations. Because they are primarily related to the generation of accounting information, these controls, more than any others, will be affected by the postulated system.

Document controls.—The document controls are designed to assure the auditor that all documents have been accounted for. This implies control over both the issuance and processing of documents. In both cases, the specific controls are identical; therefore, no differentiation will be made between a control being used as a check on usage of documents and the same control as part of the processing procedure.

Control over documents is accomplished by identification of the documents when they enter the system, followed by repeated identification at subsequent points in time. There are two types of document controls: batch controls and sequence controls. Control over a group of documents taken as a set is obtained by using a batch control. When this system is used, a control total referring to the entire set is established as early as possible. This total need not be meaningful because its sole purpose is to uniquely determine the number of elements in the "batch." Therefore it is possible to establish any
total meeting this requirement for control purposes, e.g., the number of holes punched in a set of cards might prove useful in some situations, even if the total has no other meaning. Numbers of this kind are usually referred to as "hash" totals.

Because batch controls do not provide a check on individual documents, **sequence checks** are used where individual document control is important. In this method each document in the set is assigned a designation which is uniquely determined by the designation assigned to the preceding document in the sequence. Most commonly, this means that a number is assigned to each document and that number is one greater than the number assigned to the preceding document.

**Computational controls**.—The computational controls are designed to assure the arithmetic of a process. This is accomplished in two ways: using redundancy, and using logical interrelationships. Redundancy, in this context, means using independent duplication of processes as a check on calculations. This may take place either when results of identical operations are compared or when the basic laws of arithmetic—associativity, commutativity and distributativity—are applied. Closely related to the latter method is the use of the logical interrelationships within a program as a basis for checking computational validity. Consider a payroll problem, for example: a comparison of the computed, accumulated social security deduction may be made with the statutory maximum. An accumulated deduction in excess of this maximum indicates that an error has been made.
Effect of the postulated system upon accounting controls

The evaluation of the accounting controls is presented in a manner consistent with that followed for administrative controls, i.e., an historical approach is taken, tracing the development of data-processing from punched-cards to the postulated system. It is shown that the steps leading toward the postulated system give the auditor added confidence in the accuracy of the system's output.

Document controls

Document controls have as their objective assuring the completeness of the data set. They are designed to indicate the omission of data at most stages of processing.

Punched-card processing.—Punched-card processing is essentially a three-step process, viz., keypunching, sorting, and listing. Data enters the system in oral or written form. It is then transferred into machine-sensible form by punching the data into cards. It is the punches in the cards, not the original data, that are sensed by the individual machines during processing.

The advent of punched-card equipment did not bring with it any major changes in document control. In manual data processing it was found that data are most efficiently processed where people specialize in a particular part of the processing and where the data are divided into smaller groups. The division of data into groups permits control over the groups and permits the human processors to achieve satisfaction of their goal seeking needs. The most common method for assuring the
completeness of the data set was the use of sequence checking. Using this technique, all documents (often only the more important documents) are prenumbered. By sorting the documents in sequential order and then checking for missing numbers, control over the data set is achieved.

With the switch to punched-card processing, it was still possible to sequence check records. Document numbers could be punched into the cards. These cards could then be checked almost automatically for sequence, by first sorting them and then sequence checking with a collator.

Since punched card equipment operates on punched cards without any reference to the contents of the cards, additional controls may also be instituted for the control of the batches. Once the size of the data set has been established, control totals may be established that control either the size of the set or both the size and the contents of the set. For example it may suffice for some operations to determine only the number of items in the set without reference to the contents of the individual items. In such a situation one might establish as a control only this number, continually checking the number of documents processed against the control. On the other hand it may be deemed necessary to establish a more complete control over both the number of items in the set and the contents of the individual items. To meet this need one generally establishes a more meaningful total such as the sum of the debits to accounts receivable that are contained on the credit sales cards. A test of this kind controls the contents of the records, and by inference, controls the number of records.
Since the punched card equipment does not require that these totals make sense, i.e., that they have non-control meaning, it is possible to establish a total of this kind using such items as the sum of the employee numbers in the payroll for control purposes.

Punched-card equipment does not have the ability to check the completeness of the set. While it is conceptually possible to use some of the equipment, such as, the accounting machine to determine whether or not there is agreement with the previously established controls, in a practical sense this is rarely done because of both the severe technological limitations of the equipment and the need for independent controls. Thus even in the punched-card processing system, control over documents was primarily manual. The results of a data-processing operation were obtained from the data-processing department and then checked manually against externally-determined control totals.

Computers.—With the advent of the computer, one begins to find more severe changes in the nature of data-processing operations. The changes were due to the increased memory capacity, higher speed and logical ability of the computer. Computers are characterized by their ability to make logical decisions and then follow a series of processing steps determined by the logical conditions then in existence. The implications of such capabilities show clearly the ability to accomplish more complete processing within the computer, thus relieving human beings of the need for performing many strictly routine operations.
Earliest computer installations were automated punched-card processors. They were direct conversions of existing punched-card processes and did not take advantage of the increased capabilities of computers. To the extent that this was the case, there were no changes from the then existing internal control conditions.

As businesses recognized the decision-making capabilities of computers, the scope of the systems increased. There still remained the need for control into and out of the system; however control over data transmission within the system was largely programmable. The program could test (1) the availability and conditions of input/output or memory devices needed for the program, (2) the completeness of both the data set and the individual records comprising the set, (3) the correctness of data transmissions, and (4) the correctness of the data format. These tests are described in Table 9.

With the increase in the scope of the system the auditor was faced with two changes in the internal control of documents. On the one hand he had added confidence in the execution of system checks through evaluation and control over the program. At the same time, however, came the substantial decrease in the number of times that data either left the system or was converted into human sensible form. The ready availability of large scale random or semi-random access memory meant that large portions of data processing could be accomplished without any human intervention. It was not long before many programmers realized that much of the system's output was necessary only to facilitate human processing, much of which had been replaced by
<table>
<thead>
<tr>
<th>Control</th>
<th>Purpose</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Format Test</td>
<td>Determine whether input or output data is in form specified within computer program</td>
<td>Character by character examination of input or output records, comparing type of character (alphabetic, numeric, blank, or special) with program requirements</td>
</tr>
<tr>
<td>Availability Test</td>
<td>Insure availability of all input, output and memory devices required for the execution of the program</td>
<td>Programmed check of input, output and memory devices. Tests status of component, physical availability, operating conditions, and switch settings. These tests are accomplished by transmitting a signal to the device and then comparing the returned signal with program specified norms</td>
</tr>
<tr>
<td>Character Transmission Test</td>
<td>Determine whether a program specified character (usually a blank or a zero) has been transmitted instead of data</td>
<td>Comparison of character transmitted and specified character. An unequal comparison indicates that the specified character has not been transmitted</td>
</tr>
</tbody>
</table>
### TABLE 9--Continued

<table>
<thead>
<tr>
<th>Control</th>
<th>Purpose</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Completeness Test</td>
<td>Determine whether all parts of a multi-record transaction have been transmitted in the correct sequence</td>
<td>Comparison between characteristics of fields in record and program specifications. In absence of part of the record the transaction may be completed by using a predetermined field in the place of the missing data, or the transaction may be rejected.</td>
</tr>
<tr>
<td>Control Total</td>
<td>Same as Completeness Test</td>
<td>Comparison between a total developed from specified fields and a pre-established control total. When the total is comprised of seemingly meaningful fields, e.g., sales, it is referred to as a batch total. Otherwise it is called a hash total.</td>
</tr>
<tr>
<td>Echo Check</td>
<td>Determine whether data has been correctly transmitted</td>
<td>Data received is retransmitted and then compared with the original data. This test is also used in connection with input and output operations, e.g., immediately after a printing operation takes place a comparison is made between the position of the printing heads and the program determined character that was to be printed</td>
</tr>
<tr>
<td>Control</td>
<td>Purpose</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------</td>
<td>--------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Parity Check</td>
<td>Determine whether there have been any deletions or additions to the transmitted signal</td>
<td>Addition of an extra signal to the representation of a character so that the sum of the signals comprising the character are even (even parity) or odd (odd parity). A common system in current use requires that four out of eight signal be used to represent a character</td>
</tr>
<tr>
<td>Record Count</td>
<td>Same as Completeness Check</td>
<td>Comparison between number of records received and a previously established total. See also Control Totals</td>
</tr>
<tr>
<td>Sequence Check</td>
<td>Same as Completeness Check</td>
<td>Comparison between index and identification contained in record. Usually used where close record control is necessary</td>
</tr>
<tr>
<td>Alteration Test</td>
<td>Determine whether intended changes have actually taken place</td>
<td>Comparison of contents of affected memory area before and after intended change takes place</td>
</tr>
</tbody>
</table>
**TABLE 9—Continued**

<table>
<thead>
<tr>
<th>Control</th>
<th>Purpose</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crossfooting</td>
<td>Determine validity of arithmetic operations</td>
<td>Repetition of operation using totals of individual arithmetic operations</td>
</tr>
<tr>
<td>Dual Arithmetic</td>
<td>Same as crossfooting</td>
<td>Repetition of individual arithmetic operations using either dual circuitry or commutative laws of mathematics</td>
</tr>
<tr>
<td>Logic Test</td>
<td>Determine whether symbols, requests, magnitudes and combinations are consistent with program being processed</td>
<td>Comparison of symbols, etc., with programmed standards determined from logic of the problem</td>
</tr>
<tr>
<td>Proof Figures</td>
<td>Same as crossfooting</td>
<td>Use a distributive law of mathematics to prove validity of arithmetic operations</td>
</tr>
<tr>
<td>Overflow and Underflow Test</td>
<td>Determine whether significant numbers have been lost as a result of arithmetic operations</td>
<td>Test contents of accumulator after arithmetic operation has taken place in order to determine whether result was of sufficient magnitude to result in loss of significant digits</td>
</tr>
<tr>
<td>Control</td>
<td>Purpose</td>
<td>Description</td>
</tr>
<tr>
<td>-------------------------</td>
<td>----------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Self-Checking Number</td>
<td>Determine whether original coding of documents is valid</td>
<td>Addition of a digit to account numbers such that the additional digit is uniquely determined by the preceding digits. The coding is checked by recomputing the check digit within the computer and then comparing the recomputed digit with the digit on the encoded document.</td>
</tr>
<tr>
<td>Sequence Check</td>
<td>Determine whether all documents have been processed</td>
<td>See Sequence Check under data transmission</td>
</tr>
<tr>
<td>Valid Code Test</td>
<td>Determine whether identification associated with a record is valid</td>
<td>Maintain a list of valid document numbers within the computer and then compare document numbers with this list.</td>
</tr>
<tr>
<td>Zero Divisor Test</td>
<td>Determine whether division by zero is taking place</td>
<td>Test divisor prior to attempted division</td>
</tr>
<tr>
<td>Control</td>
<td>Purpose</td>
<td>Description</td>
</tr>
<tr>
<td>-------------------------</td>
<td>--------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Identification Check</td>
<td>Determine whether data and files are logically consistent with program</td>
<td>Similar to logic test. Comparison of identifying characteristics with logically determined standards. For example, a check may be made of all tapes to determine whether their contents are logically consistent with the program requirements.</td>
</tr>
<tr>
<td>Program Hash Total</td>
<td>Determine whether changes have taken place in the program</td>
<td>Determine a hash total of all instructions in a program. Compare this predetermined total with a similar total developed during the execution of the program</td>
</tr>
</tbody>
</table>
computers. Thus it was natural to suggest alleviating the input/output bottleneck by eliminating the superfluous output. There are two difficulties caused by this elimination of written records: (1) apparent loss of an audit trail and (2) recognition that account updating in such a system is destructive, i.e., often only the most current balance is stored, with older ones destroyed and unrecoverable.

The first of these difficulties is postponed for consideration in the next chapter. At this time the second problem is considered.

There are two approaches that may be taken toward a solution of the destructive storage problem. The easiest, and presently most common, method requires the preparation of a "transaction register." This register often contains such items as transaction identification, accounts affected, and "before" and "after" reproductions of the affected accounts. This register, if prepared, is for the use of the auditor—it serves few other purposes, e.g., data recovery.

An alternative to the use of a transaction register is to simulate its use on a computer. A character test may be performed to determine whether one is about to store blanks or zeros in the place of meaningful data. This test, in effect, eliminates some of the errors before any damage has been caused. Where the test indicates that the program is functioning satisfactorily, an alteration test may be

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17 In most computer systems there was a wide discrepancy between internal computation speeds and input/output speeds. Thus the maximum capacity of the computer was often determined not by its speed or storage capacity but by the slower speed with which its input/output devices worked.
performed. First the content of the storage area that is about to be affected is duplicated in a temporary storage area. Second, the account is then updated, thus destroying the old contents of the storage area. Last, the new contents of the storage area are compared with the temporary storage (the old contents) to determine whether a change has in fact taken place. If a change has taken place it may be assumed that the updating has taken place satisfactorily.

The simulation of the transaction register has not yet gained full acceptance by the auditor as a substitute for actually printing out the register and tracing transactions by hand. Nevertheless, it does represent a first indication of a place where a continual audit takes place. The test, if constructed independently of the remaining program, is as satisfactory, if not more so, than an independent audit at the end of the fiscal period.

**Postulated system.**—In the postulated system the auditor will be faced, for the first time on a major scale, with an inability to utilize batch controls for regulating the input and output from the system. This follows from the fact that the system will contain numerous input/output units scattered over the range of the firm's operations. In the postulated system, an input/output batch will consist of a single item.

The inability to use batch controls will not eliminate all control over documents. Sequence checks will be available in the system but there will be a reduced need for document controls as such.
All input units will be on-line with the central computer. Thus echo checks\textsuperscript{18} may be used to provide assurance that data entering the system at one of the input units is correctly received by the computer. Once the data has been received by the computer, it is maintained within its memory and is subject to the controls discussed previously.

A spin-off of the batch control problem arises because exceptional items will be rejected from the system and designated for human intervention. In such cases there will have to be assurance that the rejected items eventually find their way back into the system and that no duplication of processing takes place as a result of the exception-transaction process.

There are several techniques that may be used to control exception processing, all of which rely upon the existence of standard procedures which must be followed in every case. Some examples of these techniques are listed below.

1. Prepare a table of valid items, such as document numbers. As a transaction enters the system, a search is made on this list; if the item is found on the list, it is deleted from the list and then processed; if the item is not on the list, further testing takes place to determine whether it resulted from a previous rejection or whether it is invalid; if the item resulted from some previous rejection then

\textsuperscript{18}Echo checking is accomplished by retransmitting data that has been received, followed by a comparison between the retransmitted data and the original source.
processing is restarted at some standard point; if the item is not valid, it is rejected to be treated as an exception.

2. Reverse all operations that were performed on the data prior to its rejection. When it re-enters the system, treat it as new data.

3. Maintain a list, within the computer, of all exception items. This list contains identification of the items, their characteristics and an indication of a restart point. If an item is found to be in this list, it is re-entering the system and thus processing should begin at the previously determined restart point.

Processing controls

The situation found when examining document controls--increasing computerization of the audit--is paralleled in processing controls. To an increasing extent, the controls that have always been applied to manual data-processing systems will still be applied, with the auditor able to obtain a greater degree of confidence in his final results.

Punched-card systems.--The coming of the punched-card and its application to business processing did not result in a loss of accounting controls--so long as organizational independence remained in existence. It was still possible to independently determine control figures and compare logical interrelationships (preparation of "reconciliations"). It was also possible, in many instances, to utilize the self-checking number feature that was available on some equipment for assurance of the validity of identification numbers. Since assurance of arithmetic reliability was obtained, for the most part, by manual reconciliations, the advent of punched-cards did not
revolutionize this aspect of the internal control evaluation.

Computers.—With the coming of computers, the need and ability to demonstrate arithmetic accuracy increased. The penalty for making an arithmetic error and having it go undetected increases, for with less external output and more continual processing the error is propagated throughout the system before it is finally discovered. Additionally, to the extent that the computer performs logical operations, it may be directed to false conclusions as a result of the arithmetic errors.

Several tests described in Table 9 are available to assure arithmetic accuracy. Certainly the computer can be programmed to perform the crossfooting operations. Similarly, dual arithmetic may be performed, using either independent computer circuitry or the commutative laws of mathematics. It has also been suggested that proof figures be developed. Since this test is not as common as some of the others, it is illustrated below:

Example
Assume that a payroll is being calculated and that no employees are paid more than $5.00 an hour. Pick any number equal to or greater than this maximum and perform the calculations shown below. For the purpose of this illustration the number $5.00 has been picked as the arbitrary constant.

<table>
<thead>
<tr>
<th>Hours worked</th>
<th>Pay rate</th>
<th>Constant and pay rate</th>
<th>payroll</th>
<th>proof</th>
</tr>
</thead>
<tbody>
<tr>
<td>40.00</td>
<td>1.50</td>
<td>3.50</td>
<td>60.00</td>
<td>140.00</td>
</tr>
<tr>
<td>15.00</td>
<td>2.00</td>
<td>3.00</td>
<td>30.00</td>
<td>45.00</td>
</tr>
<tr>
<td>25.00</td>
<td>3.00</td>
<td>2.00</td>
<td>75.00</td>
<td>50.00</td>
</tr>
<tr>
<td>40.00</td>
<td>5.00</td>
<td>0.00</td>
<td>200.00</td>
<td>0.00</td>
</tr>
<tr>
<td>35.00</td>
<td>4.50</td>
<td>0.50</td>
<td>157.50</td>
<td>17.50</td>
</tr>
<tr>
<td>155.00</td>
<td></td>
<td></td>
<td>522.50</td>
<td>522.50</td>
</tr>
</tbody>
</table>
From the distributive law of mathematics it must follow that
Total hours worked × constant = total payroll + proof

\[ 155.0 \times 5.00 = 522.50 + 252.50 \]

\[ 775.00 = 775.00 \]

In effect the computer made it possible to assure performance
of many controls formerly performed manually. This did not, however,
eliminate the need for manual reconciliation of interrelated amounts.
The computer systems were still batch process oriented and as such
always contained considerable "float"—items recorded in one place
but not in another.

**Postulated system.**—The postulated system will contain all of
the abilities of an ordinary computer system plus some in addition.
The simultaneous, or near simultaneous, processing of all items
affected by any transaction plus the immediate availability of all
information, will increase the ability to utilize tests of logical
relationships. There will be no need to adjust for float.

The existence of a monitor and its centralized control over the
operations of the entire system will make it possible to utilize
several additional controls. The monitor will make it impossible for
the operator to gain access, physically or logically, to specified
parts of the system. It may thus be used to maintain a log of
computer operations. This log will contain (1) a list of errors
together with an indication of the type of error, possible cause of
the error, and actions taken as a result of the indication, and (2)
operator interventions, including operator identification, program
identification, nature of intervention, items affected by the
intervention, and operation performed immediately after the intervention.
The existence of such a log will make it possible for the auditor to obtain a numerical measure of the system's reliability.

Summary and Conclusions

The first step in most audits is assumedly the evaluation of internal controls, for it is this evaluation which provides a basis for determining the limits of the extended auditing procedures. To the extent that the auditor is able to convince himself that internal controls exist and are working satisfactorily, he has a basis for reducing the extent of his testing.

Internal control has been divided into two separate areas—administrative controls and accounting controls—for the purpose of this analysis. Controls do not fall entirely within either of the areas, for a control concerned with the administration of the business is also concerned with the financial records and the assets of the firm. For this reason the division of specific controls into one of these classifications is, here and elsewhere, on an almost arbitrary basis.

The analysis of the effects that the postulated system will have upon both internal controls and the auditor's evaluation of internal controls was accomplished by treating the postulated system as a point on a continuum. The developmental continuum begins with the manual data collection and classification system that provided the basis for the traditional books on auditing; it ends, for the current purpose, with the postulated system, after having passed through stages of progressive automation of these processes.
Administrative controls, as such, are not generally evaluated by the independent auditor. Instead they are used to provide him with supplements to other, more specific, evaluations which are directed toward the financial statements.

The postulated system will be, at the same time, more rigid and more flexible than business systems currently in use. It will be more rigid because the severe computer orientation will necessitate adherence to computer program formats and rules. The ability of the computer to monitor both its own actions and those of the employees means that there will be possible a more straightforward evaluation of whether established procedures are being followed. In a sense this may be summarized by saying that the employees of the firm will, in effect, become semi-autonomous extensions of the computer-oriented system.

Systems under the postulated conditions will also be more flexible than those currently found. Since the system is constrained to meet all possible managerial needs, it will have to possess facility of modification. This ability to modify itself or be modified implies a smoother, more rapid reaction to changing needs than is currently possible. There is no inconsistency between the statements regarding rigidity and flexibility since the areas of interest are not identical. Flexibility, the ability to make changes in the system, will exist. Once the characteristics of the system have been established, adherence to system constraints will be more formal and hence more rigid than is currently the case.
Within the postulated system there will be organizational separation even though there is a strong indication that many firms are recentralizing geographically. The separation, and hence the related control, come from the complete divorce of the mechanical part of the system from the other organizational units of the firm. The resulting organizational structure will be such that the people operating the computer and computer-related portions of the system will lack the technical and educational ability to affect the system. Those who do have the ability to affect the system, the programmers, will be organizationally and geographically separate from the computer.

A large portion of both the evaluation of internal controls and the subsequent auditing procedures deal with assurances regarding documentary procedures. The auditor investigates the procedures followed in the firm in an attempt to determine whether all of the valid documents, and only these, have been fully accounted for at all relevant points in the business system. In the manual system this meant that both the internal and independent auditors spent much of their time utilizing logical relationships existing throughout the system. This reconciliation procedure has been, for the most part, a manual process because of the large portion of data "float" throughout the system. The data "float," however, resulted from the batching nature of the processing. For this reason the postulated system will not contain nearly as large a "float" and will be able to continually reconcile itself.
The implications of the postulated system for the internal auditor are clear. He can ascertain the existence and operability of a large portion of the controls by examining the computer program. Having made this examination, he can then be assured of the continuing operation of the controls by maintaining control over the program. This need for control over the program is simplified by the complexity of the program, organizational separation of duties, and the central, semi-dictatorial position of the monitor. Since the internal auditor needs spend less time with detail, he is in a position to place added emphasis upon the development of administrative controls and investigations regarding the efficiency of operations.

The shift in the nature of the internal auditor's emphasis combines with the other more mechanical qualities of the system to imply a change in emphasis by the independent auditor. To the extent that controls have become automated, and to the extent that the entire system has been mechanized, it will be possible for the independent auditor to formalize his evaluation of internal controls. With the increased formalization of this analysis, it should be possible for the independent auditor to obtain more confidence in an evaluation, and hence it will have a far-reaching impact on the remaining audit tests. These tests are discussed in more detail in the following chapter.
CHAPTER VII

EFFECT UPON AUDITING PROCEDURES

If it is possible for the independent auditor to obtain assurances that all possible internal controls are both present and working satisfactorily, then the need for many auditing procedures is eliminated. Under these circumstances it would follow, as a matter of nature that data is being correctly processed and assets are being satisfactorily protected. Eliminating those procedures designed primarily for assurances regarding arithmetic accuracy or the verification of the existence or non-existence of assets or equities, leaves only that part of the audit function dealing with the adequacy of disclosure. Supplementary auditing procedures, then, are necessitated only by the absence of effectively-operating internal controls.

Nature of the extended procedures

In the absence of total confidence in the effectiveness of internal controls, the auditor must attempt to satisfy himself regarding financial statement representations by using other means. By using other means, it is meant that the auditor relies upon his traditional procedures to fill in the gaps. These procedures are a modification of the classical "scientific method" of observing.
conditions, formulating hypotheses, testing the hypotheses, and then either accepting or rejecting the hypotheses. The scientific method is not a technique for cutting short the process of discovery.

Instead, it is a mental attitude, one of persistent skepticism.

The practice of scientific method is the persistent critique of arguments, in the light of tried canons for judging the reliability of the procedures by which evidential matter are obtained, and for assessing the probative force of the evidence on which conclusions are based. As estimated by standards prescribed by the canons, a given hypothesis may be strongly supported by stated evidence. But this fact does not guarantee the truth of the hypothesis, even if the evidential statements are admitted to be true—unless, contrary to standards usually assumed for observational data in the empirical sciences, the degree of support is that which the premise of a valid deductive argument gives to its conclusion.

The auditor, following his standard of "Due Care" modifies this tried and proven technique to meet his specific needs. Given an audit engagement, the auditor makes a preliminary observation of the relevant facts (including the internal controls), and then subdivides the composite into several individual problems for separate testing. The results obtained in each of these minor evaluations will later have to be combined before the auditor can rule on the financial statement representations as a whole.

1Nagel, p. 13.

2It is not valid to assume that this implies equal weighting to each of the minor problems, for such is not the case. The importance of a given problem is determined by the relative importance of the related presentations to the statements as a whole. To the best of this writer's knowledge, no definitive attempt has yet been made to quantify the nature of this interrelationship.
Since the audit is performed under severe time restrictions, the auditor, in absence of indications to the contrary, hypothesizes that the financial statements prepared by the client adequately reflect reality—the auditor's reality. After examining the nature of the audit evidence available, relative to one of the subdivided problems, he then uses those procedures that are assumed to best combine with the internal control evaluation to prove or disprove the hypothesis. After performing the chosen procedures, the auditor evaluates the evidence—with respect to pertinence and validity; for indications of any additional problems; and with respect to adequacy for judgment formation—and then formulates judgments on both the individual problems and the composite representations.

In the course of his audit, the auditor is not always able to prove or disprove his hypothesis. In this sense, due to the current state of the auditing art, proof must be defined not only in statistical terms but in terms of influence upon the mind of the auditor. Mautz and Sharaf present a division of auditing assertions according to the extent to which compelling evidence is available.

**Assertions for which compelling evidence is available**
- Existence of physical things if present
- Single quantitative amounts
- Mathematical assertions

**Assertions for which compelling evidence is not available**
- Existence of physical things which are not present
- Existence of nonphysical things
- Nonexistence of physical and nonphysical things

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3As shown earlier the auditor’s concept of reality is generally restricted by the burden of conformity to AICPA pronouncements.

4Mautz and Sharaf, p. 27.
Occurrences of past events
Amounts involving value judgments
Qualitative conditions whether expressed or implied

One need not assume that this will always be the case, for as more sophisticated procedures become available to enable more reliable testing of some of the assertions, compelling evidence will also become available regarding some of the latter items listed by Mautz and Sharaf. This statement assumes that, as these more sophisticated techniques become available, there will be a proportionate increase in the educational level of the auditors so that the results will indeed be compelling—an assumption necessary since compulsion is a psychological concept.

In the remainder of this chapter several facets of the extended procedures are examined—the audit trail and auditing procedures, plus the recently prominent tool of simulation. The purpose of this examination is to demonstrate that under conditions which will exist in the postulated system, the auditor will be able to obtain at least as much—probably more—compelling evidence than is possible under current conditions. It is further asserted that this evidence will be more objective than current evidence, since it will be quantifiable to a larger extent, and that it will be obtainable with less effort than is currently required in the evidence collection process.

\[5\text{Ibid., p. 84.}\]
Affect of the Postulated System

The audit trail

The documents, journal entries, postings, worksheets, and so forth provide a logical sequence that may be utilized by the auditor to trace transactions from their origin to their final destination—the financial statements. This sequence is generally referred to as the audit trail. It provides the auditor with the ability to perform the process described above and to reverse this same procedure, tracing from the financial statements to their origin.

The auditor must use this trail in both directions to verify the two forms of assertions made on the financial statements. These statements assert that the assets, liabilities, owner's equity, and net income exist as stated—both in total and with respect to the individual components. They also assert that there are not additional items which have not been disclosed.

Effect of changes in data-processing.—In the non-EDP accounting system the audit trail consists of the documents, journals, ledgers, and so forth. These "signposts" exist naturally within the system, i.e., they exist as part of the data collection and classification process; they are not created solely for the use of the auditor. The audit procedure, in such a situation, is to validate selective signposts by the use of various techniques—refooting and crossfooting, reconciling, and tracing selected documents from signpost to signpost—and then make inferences regarding the financial statement representations taken as a whole.
The increase in the volume of processed data that has been generated by the growth of businesses has led the auditor to become more formalized in his testing procedures. Where he once examined all of the transaction before arriving at a conclusion, he now examines a statistically selected sample which is assumed to be representative of all the transactions. Even with this sampling procedure it may be necessary to test each of a particular kind of transaction to obtain the desired level of confidence.

Initial steps in the automation of data-processing did not alter the nature of the audit trail. However, as the automation process progressed, the audit trail began to undergo significant changes. In this respect Grody refers to the "growing obscurity of the audit trail" and Kaufman and Schmidt write of the absence of journals, registers and prior postings in the accounts. The automation process carries with it corresponding losses of concrete signposts. This loss is due to a progressive decrease in the amount of "hardcopy," printed material resulting from the processing. With the absence of hardcopy the auditor had two alternatives (1) he could require that the printed output be prepared for his use, even though it was not needed as a basis of further processing; or (2) he could

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6 cf., pp. 121-127.


9 cf., p. 142.
compensate for this loss by increased reliance upon internal controls. No consideration will be made of the first alternative since it does not represent any change in the data processing methodology. It is improbable that businesses will be able to rationalize economically the continual production and storage of records that are useful only to the auditor. This is especially the case since it is asserted that more efficient and less costly methods are available for accomplishing audit objectives.

The growing obscurity of the audit trail\(^ {10} \) caused a controversy regarding the need for examination of computer programs and the degree of reliance that might be placed on computer oriented and operated controls. It is sufficient for the auditor to reconcile a sample of the original documents with the financial statements? Or must the auditor literally dissect the computer program to trace the step-by-step processing? It is asserted that neither of these approaches, taken by itself, provides a satisfactory solution to the problem.

The postulated system.—Several factors in the postulated system combine to provide a straightforward solution to the "in or around" controversy described above. These factors are (1) internal control conditions\(^ {11} \), (2) the scope and complexity of the system and (3) the

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\(^{10}\)There is no agreement that the audit trail has been obscured. Some authors feel that it has only been altered. For example, see Kenneth Cadematori, "Auditing Automated Data Processing," *The Federal Accountant*, (June, 1959), pp. 25-31.

\(^{11}\)Internal control conditions were presented in Chapter 6 and will not be considered again.
nature and timing of the audit performed by the independent auditor.

The scope of the postulated system will encompass all of the operations of the firm. This follows from the requirement that it meet all possible informational needs of management. This system will be oriented around a huge, centralized computer which is capable of making programmable decisions while it is meeting managerial information requirements.

From the conditions set forth above it can be seen that the computer program necessary for the operation of such a system will necessarily be both large and complex. This size and complexity will not preclude the need for periodic revision of the system to meet changing needs and conditions. Thus while it was shown that, in spite of the apparent complexity, there will exist the facility to modify existing programs. Modification will be possible only if one can obtain knowledge of all interrelationships existing in the system—knowledge obtainable only through the maintenance of a complete cross-reference file showing program and data interrelationships.

The increased size and complexity have several implications for the independent auditor: (1) it will be increasingly difficult for

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12 As shown in Chapter V, the program will consist of several smaller subprograms. For the present purposes, however, it suffices to treat it as if it were a single program.

13 The existence of such a file carries with it certain related dangers. However, these may be dealt with through properly operating internal controls. At the same time these apparent dangers are certainly no more serious than those associated with some other aspects of the business operations.
Unauthorized persons to make changes in the system. (2) It will be
unfeasible to trace through programs each and every time an audit is
performed; and (3) information regarding existing interrelationships
will be more readily available, if needed, than is currently the case.
These factors combine with the earlier remarks regarding internal
controls to give the auditor more confidence in computer processing and
to reduce the need for detailed tracing of computer programs at each
audit. It is shown in the next section that the timing and nature of
the audit will change, with the emphasis being away from year-end audits.

The auditing process

The increased reliance upon internal controls combines with the
scope and complexity of the system to indicate that the auditor will no
longer perform a detailed, year-end audit. Instead there will be a
continuing audit taking place throughout the year, with reliance upon
internal controls to detect changes taking place between the time of
the audit and the financial statement date. It is even conceivable
that at some future date the audit will consist of nothing other than a
detailed review and test of the accounting system which would lead to
acceptance of the resulting financial statements.

Computer audit programs.—The postulated management information
system will itself be an important tool in auditing! Since the system

14 William E. Whitmer, "Electronic Data Processing, Its Effect on

15 Howard J. Doherty, "The Effect of Electronic Data Processing
on Auditing," MISQ, X (April, 1965), p. 3.
is oriented around the computer, the auditor may utilize the computer as a mechanical aid while performing the audit. Certainly some advantages may be obtained from this approach. However, the auditor will be able to use several characteristics of the postulated system to go beyond this point, viz., (1) most computer systems operations are under monitor control and (2) many auditing procedures, and the decisions based upon them, are of a routine nature. It therefore follows that the monitor itself may be utilized to perform a continual audit of operations throughout the year.

Baumle describes a similar system, with more limited scope, that is currently in use.16 In the case described, the program is not run continually but is run under the auspices of the firm's internal audit department. This program audits the accounts receivable; it checks the clerical accuracy of the trial balance of accounts; it independently calculates the time-price differentiated ending balance for each account; it selects controls to be audited; it selects accounts for confirmation; and it prepares negative confirmation requests.

Simulation.—The simulation technique of auditing is not new. It is discussed by Corcoran and Istvan in connection with the detection of fraudulantly used zone punches on punched card equipment.17 In this approach a deck of punched cards is prepared, testing all of the possible positions and combinations of positions in which zone punches


17A. Wayne Corcoran and Donald Istvan, The Audit and the Punched Card: An Introduction, (Research Monograph Number 101; Columbus, Ohio: The Ohio State University Bureau of Business Research, 1961), p. 15.
might occur. The simulation deck is then processed through the equipment to determine what action will be taken.

Similar processes have been used to test computer programs. The auditor prepares a set of data consistent with the format required by the client's programs and then processes it. The results obtained using this simulation deck are then compared with known results that the auditor has previously obtained.

As the computer system becomes more sophisticated a parallel change in the simulation approach may be found. In one case where the audit trail has allegedly disappeared, Benjamin describes the use of this approach. The case he describes even lacks input documentation that is independent of the computer system. Factory workers report time (both job and attendance) by using their employee badge and an IBM 353 "Transacter." Aside from the evaluation of flow charts and computer programs, the auditors utilized a set of carefully prepared, dummy transactions. These dummy transactions were processed, without prior notice to the plant personnel, along with the daily transaction. The actions taken, both by the computer and the plant personnel in response to these transactions were observed and then used as a basis for final acceptance of the computer generated data.

Input/output on the postulated system will be achieved with a series of on-line units. (See Figure 7) One of these units may be

located on-line and controlled by the auditor. Thus, at command, he can obtain any information needed. More importantly, though, he will be able to simulate the input of fictitious data to enable observation of the system's reactions. Utilizing such a medium, the auditor can test not only the veracity of the traditional accounting portion of the system but also the operation of the system as a whole.

The stated objective for the postulated system has been to meet any and all of management's information requirements. This, taken together with the need to formulate an opinion based upon the performance of the system as a whole, suggests that the auditor would have to take a position regarding the availability of data for decision-making. If it is asserted that this position includes either non-financial statement related data, or data relevant only to future decisions, then there is a strong suggestion that there be expansion of the audit in the direction of a management audit. The problems related to this step are both numerous and beyond the immediate scope of the analysis.

A measure of system reliability.—The purpose of this section is to suggest the capacity of obtaining a quantifiable indication of system reliability. This measure is obtainable for several reasons, not the least of which is that elimination of human data-processors and the substitution of machines in their place, reduces the number of unknowns in the system. Unlike human beings, computers and related
peripheral equipment continually perform their assigned tasks consistently and give indications when the expected pattern is broken. It is therefore possible to derive a probability measure for the system as a whole.

Briefly, if we let \( P(M_i) \) be the probability that the ith component in the system is operating satisfactorily, then the probability that an entire series system\(^{19} \) is operating satisfactorily is given by:

\[
P(S) = P(M_1)P(M_2) \cdots P(M_{n-1})P(M_n)
\]

Similarly, the probability that an entire parallel\(^{20} \) system is operating satisfactorily is given by:

\[
P(S) = 1 - P(M_1)P(M_2) \cdots P(M_{n-1})P(M_n)
\]

Of course most business systems are not entirely in either one of these classifications but are a combination of both.

The data for the measures of systems reliability may be obtained from: (1) monitor maintained frequency distributions (2) maintenance records (3) manufacturing engineering specifications; and (4) formulae such as the one derived in Appendix A.

The purpose of this section was not to derive a measure of system reliability. Instead, it has been demonstrated that the

\(^{19} \)A system consisting of \( n \) components is said to be in series if the successful operation of the system depends upon the successful operation of all \( n \) components.

\(^{20} \)A system consisting of \( n \) components is said to be in parallel if the successful operation of the system is implied by the successful operation of any one of the \( n \) components.
increased automation of the postulated system will make it conceivable for the auditor to obtain such a measure. Thus, for the first time the auditor will have a quantifiable measure of system performance that he can use as a basis for his final audit decision—whether or not he should associate himself with the representations made on a set of financial statements.

Summary and Conclusions

The auditor evaluates the internal controls of a business as a basis for determining the extent of his subsequent tests. Thus one finds that the postulated system places the auditor in an interesting, although not the least bit uncomfortable, position. On the one hand, it was shown that the independent auditor will be able to obtain more confidence in the satisfactory operation of the internal controls in the system. This leads to the obvious conclusion that the extent of the remaining audit tests may be reduced. Yet, on the other hand, it has been found in this chapter that the auditor is able to perform better more of the tests in the postulated system than was the case previously.

The auditing process is a search for evidence needed to support hypotheses. In the process, the auditor divides the problem, of forming a judgment on the financial statements as a whole, into a series of smaller problems. It is only after he has arrived at an opinion regarding these individual problems that an attempt is made to combine them into an overall judgment.
One important method that has been used by the auditor, as part of this process, consists of tracing the processing of transactions throughout the system. This process requires the existence of landmarks that the auditor may use for reference, e.g., documents, journals, or ledgers. With the progressive automation of the information system, the existence, at least in a form that the auditor can use, of these landmarks, decreases. Perhaps this does make it more difficult for the auditor to perform his traditional audit but it does not make it impossible for him to receive the confidence necessary for the issuance of an opinion. On the contrary, the opposite is the case.

In the postulated system the auditor will be able to rely upon the strong internal controls, the size and complexity of the system, the computer orientation of the system, and the monitor control over computer operations. Since many of the auditing procedures are routine, or at least programmable, a larger portion of the audit may be run continually as part of the daily processing of transactions.

There has been increasing utilization of dummy transactions for the simulation of systems operations. This method will not only be useful in the postulated system, its scope and power as a tool will be expanded beyond limits currently known. The auditor, with an on-line input unit at his sole disposal, will be able to enter fictitious transactions and then observe the operation of the system.
Observation in this sense is not limited to the accounting system alone, but encompasses the entire scope of the business operations. The decreased time interval necessary for processing data and the ability of the auditor to more adequately observe operation of the system as a whole both permit the auditor to obtain more confidence in his source of evidence because he will be shifting from the use of authoritarianism to pragmatism as an ultimate source of knowledge.

In the last part of the chapter the feasibility of deriving a measure of overall systems reliability is presented. While there is much theoretical effort that must precede such an attempt, the increased automation of the system definitely increases the probability that this point will be reached.
SUMMARY AND CONCLUSIONS

Business firms retain the services of independent auditors to add confidence to the representations contained in their financial statements. This is accomplished by having the independent auditor associate his professional reputation with these financial statements. The auditor's opinion, the means by which he associates himself with the financial statements, is not dichotomous; he can add varying degrees of confidence to these representations.

The auditing process.—Under ideal conditions the auditor could establish levels of confidence necessary before formulating an opinion regarding the financial statement representations. He could then withhold any judgments until he had examined a sufficient amount of data to achieve this level of confidence. Unfortunately this is usually not possible. The auditor must render an opinion regarding the financial statements within a relatively short time interval after the close of the fiscal period. This means that the auditor must be selective in his choice of evidential types and evidential methods, choosing those methods and types that will yield him the greatest degree of confidence in the limited time interval.

The evidence that the auditor is able to obtain varies in both quantity and quality. The concept of quantity is straightforward. Quality of evidence, on the other hand, is a less clear concept.
Auditing evidence is of high quality if it is a strong source of knowledge and if it is compelling to the mind of the auditor. There are several philosophical concepts generally listed as sources of knowledge: authoritarianism (testimony of people or documents), mysticism (intuitively obtained evidence), rationalism (reasoning from universals to particulars), empiricism (perceptual evidence*), and pragmatism.

These sources are not equally compelling. Authoritarianism, a commonly used source of knowledge by the auditor, must derive its validity from nonauthoritarian sources. Thus the distance between the non-authoritarian source and the auditor determines the validity of his knowledge.

**Characteristics of the postulated system**.—One of the more significant developments affecting auditors in recent years has been the application of electronic data processing equipment to business problems. With each advancement in data processing technology there have allegedly been changes in the audit process, i.e., in internal controls and the subsequent auditing procedures. The changes arise due to transitions in the available sources and forms of evidence.

In an attempt to investigate the effects of electronic data processing upon the availability of audit evidence, a management information system has been postulated. No assertion is made that any system possessing these characteristics will ever exist—although recent technological and economic trends are increasing the probability of its development. The objective has been to postulate a system that
in some senses possesses some extreme data processing characteristics, thus placing stresses and strains on the auditing process.

A single criterion was used for the purpose of the postulation, viz., the management information system must be capable of meeting all possible information needs of management—including external reporting requirements since this is definitely a managerial need. It must be able to provide any information needed for the execution of the managerial functions—planning, organizing, directing and controlling.

To meet all of the management information requirements, the management information system will have to possess characteristics related to timeliness, reliability, scope and flexibility. It follows that a system meeting all managerial needs, with these characteristics, would permeate the entire firm; it would consist of many sub-systems, e.g., the accounting system, which together range over the entire scope of the firm.

The accounting system would ordinarily provide a natural framework for the development of the management information system; however, it possesses limitations because of its specialized orientation toward the measurement of financial transactions. Thus, rather than being the management information system for the firm, accounting becomes a sub-system of a much larger system designed to meet all managerial information requirements.

Internal controls.—As examination of the postulated system reveals that the independent auditor will be able to obtain more confidence in the overall operation of the system. This conclusion
follows from the findings in Chapter VI regarding the organization and central position of a computer in the system, the increase in the need for and adherence to formally stated procedures, and the organizational structure of the firm.

The comprehensiveness and complexity of the system lead one to conclude that it will be practicable only if it is possible to obtain an extremely large, high-speed computer. It will also follow that this computer must both occupy a central position in the system and utilize comprehensive, interrelated programs.

There will not be a single computer program running the entire system. This would be inconsistent with the requirement that the system meet all possible management information needs since it would not be feasible to make the changes necessary to meet transitory needs. Instead, the concept of modular processing will be used—building many small sub-programs which are interrelated by a central program called a monitor.

The monitor will occupy a central, domineering position in the overall system. So comprehensive will this program be that employees of the firm become, in effect, semi-autonomous extensions of a computer which is able to give them assignments, monitor their actions, and then prepare measures of their performance.

With the central position assigned to the computer, the need for the existence of and adherence to formal procedures increases. The need for formalization of procedures increases because the computer programs are in reality formal statements of procedure. Adherence to
computer prescribed procedures is assured by the close monitoring by
the computer.

Several changes will take place in the firm using the postulated
system. The computer and system may be removed from the direct control
of the financial officer of the firm. While it may be argued that such
a person has always occupied the central information supplying position
of the firm, his strong financial orientation may suggest some doubts
about his ability to adapt to the more inclusive concept of an
information system.

The separation of the information processing facility proper from
the financial offices of the firm, if it takes place, would yield more
organizational separation than is currently present. At the same time
the separation does not imply any loss of arithmetic or processing
controls from the system. On the contrary, once these checks have been
built into the computer program, assurance may be obtained regarding
their continually efficient operation. This assurance permits the inter­
nal audit staff to shift its emphasis toward the design of additional
controls and toward managerial audits.

In summary, an evaluation of the postulated system reveals the
following conclusion with regard to internal controls: (1) the scope
and complexity of the system will require the establishment of a
separate information processing department—not under the control of
the financial officer of the firm; (2) as the system expands, the need
for formally stated procedures increases; (3) the checks and controls
that were formerly obtained through separation of duties and duplication
of effort are at least as applicable in the postulated system as in
those systems that are currently in existence. By most standards,
then, the auditor will be able to achieve considerable confidence in
the internal controls of the postulated system.

**Auditing procedures.**—Supplementary auditing procedures are
utilized by the auditor as a substitute for adequate confidence in
internal controls. The postulated system will also affect these
extended procedures. First, to the extent that the additional
procedures are routine or programmable, they may be programmed and
continually executed by the computer, thus providing an audit that
continues throughout the year. Second, the use of simulation increases
in importance since the auditor will possess the capability of
simulating fictitious transactions and then observing the reaction of
the firm as a whole. And, last, it has been shown that the increased
automation in the system will bring the auditor closer to the point
where he will be able to obtain an objective measure of systems
performance. Thus in the final analysis the auditor will be able to
obtain more confidence from his audit procedures when auditing the
postulated system.

**Conclusions.**—The entire auditing process is a search for that
evidence necessary to enable the auditor to decide whether or not to
associate himself with financial statement representations. The
validity of this search rested upon his professional ability to obtain
sufficient, competent, evidential matter in the period allotted for
his audit. It has already been shown that the postulated system will
enable the auditor to obtain more evidence than before. However, the import of the system goes beyond this since there is a conceptual change in the source of the auditor's knowledge. With the shift to the computerized, postulated management information system, the weakest source of knowledge, authoritarianism, will lose its influence on the auditing process. There will be less need to rely upon such things as statements of officers and employees, documents prepared inside the enterprise, or subsidiary detail records. Instead there is a shift to pragmatism as the more important source of knowledge—examination of subsequent actions by the company and others.

In conclusion, then, it may be said that the postulated system will enable the auditor to obtain more and better confidence prior to associating his professional reputation with the representations made in financial statements. The ease with which he will be able to obtain this confidence suggests the possibility of expanding the audit function to extend beyond financial representations. The implications of such a suggestion are far reaching indeed and should provide a basis for further research.
APPENDIX A

DERIVATION OF A RELIABILITY MEASURE

The purpose of this appendix is to demonstrate the theoretical feasibility of determining a numerical measure of reliability for the components of an information system. To accomplish this we make use of the frequency definition of probability. The probability of an event A is defined as the ratio of the number of occurrences of A to the total number of observations. Thus, if we let $s$ stand for a success and $f$ stand for a failure:

$$P(s) = \frac{s}{s+f}$$  \hspace{1cm} (1.1)

since the total number of observations may be represented as $s + f$. This definition holds only where there are an infinite number of trials. However, in those cases where the total number of observations is large, the numerical value obtained will be reasonably close to the true probability.

Changing the notation used in equation (1.1), we may define the reliability of a component at any time $t$ as:

$$R(t) = \frac{N_s}{N_s + N_f} = \frac{N_s}{N_0}$$  \hspace{1cm} (1.2)

where $N_s$ and $N_f$ are the successes and failures counted up to the

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specific time t and N₀ represents the total number of observations. In a similar manner we can define the probability of failure as:

\[ F(t) = \frac{N_f}{N_0} \]  

(1.3)

The number of successes in the test are \( N_s = N_0 - N_f \). Therefore equation (1.2) may also be written as:

\[ R(t) = \frac{(N_0 - N_f)}{N_0} = 1 - \left( \frac{N_f}{N_0} \right) \]  

(1.4)

The reliability rate may be obtained from equation (1.4) by differentiating with respect to t.

\[ \frac{dR(t)}{dt} = \frac{d(1 - N_f/N_0)}{dt} = -\frac{1}{N_0} \frac{dN_f}{dt} \]  

(1.5)

Since \( dN_f \) represents the rate at which components fail, equation (1.5) may be arranged as follows:

\[ \frac{dN_f}{dt} = -N_0 \frac{dR(t)}{dt} \]  

(1.6)

But since \( N_f = N_0 - N_s \)

\[ \frac{dN_f}{dt} = \frac{d(N_0 - N_s)}{dt} = -dN_s \]  

(1.7)

At any time t, there are \( N_s \) components remaining in the test out of which \( dN_f/dt \) will fail. Dividing both sides of equation (1.7) by \( N_s \) yields the probability of failure of a single component in the test, called the failure rate \( \lambda \).

\[ \lambda = \frac{1}{N_s} \frac{dN_f}{dt} \]  

(1.8)

Substituting the results obtained in equation (1.8) back into equation (1.6) one obtains:

\[ \lambda = -\frac{N_s}{N_s} \frac{dR(t)}{dt} \]  

(1.9)
Since $R(t) = N_s/N_0$, it follows that $N_o/N_s = 1/R(t)$. Substituting this result into equation (1.9) we get:

$$\gamma = \frac{-1}{R(t)} \frac{dR(t)}{dt}$$

which is the general form of the reliability rate.

The results obtained above may be used to obtain a general formula for reliability over a period of time. Rearranging and integrating equation (1.10) we get

$$\gamma \, dt = -\frac{dR(t)}{R(t)}$$

$$\int \gamma \, dt = -\int \frac{dR(t)}{R(t)} = -\ln R(t) + C$$

$$\ln R(t) = -\int \gamma \, dt - C$$

where $C$ is a constant of integration. But since we know that at $t = 0$, $R(0) = 1$,

$$\int_{0}^{t} \gamma \, dt = 0$$

$$\ln 1 = 0$$

$$0 = 0 + C$$

$$0 = C$$

hence

$$-\ln R(t) = \int_{0}^{t} \gamma \, dt$$

Solving equation (1.11) for $R(t)$ we get

$$R(t) = \exp \left[ -\int_{0}^{t} \gamma \, dt \right]$$

An alternative formulation of the reliability function might prove useful to the reader. Consider an original population $X_0$ which is continuously changing so that there are $X_t$ items at time $t$. The change in the population in a single time interval $dt$ is $dX_t/dt$. 
The rate at which the population is changing is obtained by dividing by the total population at time \( t \), viz., \( X_t \).

\[
\gamma = \frac{dX_t}{dt} = \frac{X_t}{X_t} \frac{1}{dt} \tag{1.13}
\]

Rearranging and integrating equation (1.13), we get:

\[
\int \gamma \, dt = \ln X_t - \ln C = \ln \left(\frac{X_t}{C}\right) \tag{1.14}
\]

And at \( t = 0 \), \( X_0 = X_t \), we know that \( C = X_0 \). Thus

\[
\int \gamma \, dt = \ln X_0 - \ln C = 0
\]

\[
\ln X_0 = \ln C
\]

\[
X_0 = C
\]

Thus (1.14) may be exponentiated and rewritten as

\[
\frac{X_t}{X_0} = -\int \gamma \, dt \tag{1.15}
\]

which is identical to the result that was obtained in equation (1.12).

No assumptions have been made regarding the nature of items that are being measured, hence equations (1.12) and (1.15) are general statements of system reliability in those cases where the original population is constant and no replacement of components takes place.

Further, no consideration is being given, at this time, to the series-parallel and stand-by characteristics that may be possessed by the postulated system. Nor has any consideration of stress or maintenance levels been made.

The assumptions are obvious, unrealistic simplifications of the real world. It has been demonstrated, however, that derivation of measurements of this type are possible. Similar techniques should develop a means for handling the case where replacement takes place and where the nature of the population is continually changing.
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