To the Graduate Council:

I am submitting herewith a dissertation written by Casper E. Wiggins, Jr., entitled "Evaluating Internal Control and Alternative Compliance Testing Procedures: A Simulation Approach." I have read the final copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Business Administration.

James H. Scheiner, Major Professor

We have read this dissertation and recommend its acceptance:

Charles P. Pfluger

Accepted for the Council:

L. Evans Roth

Vice Chancellor
Graduate Studies and Research

EVALUATING INTERNAL CONTROL AND ALTERNATIVE COMPLIANCE TESTING PROCEDURES: A SIMULATION APPROACH

A Dissertation

Presented for the

Doctor of Business Administration

Degree

The University of Tennessee, Knoxville

Casper Eldredge Wiggins, Jr.

March 1982

ACKNOWLEDGMENTS

I would like to express my appreciation to the many individuals whose efforts have contributed to this study. Special appreciation is due Dr. James H. Scheiner, my dissertation chairman, for his guidance and continued moral support throughout the conduct of the study. I am also grateful to the other members of my dissertation committee: Dr. Hartwell C. Herring III, Dr. Jack E. Kiger, and Dr. Charles P. Pfleeger.

Appreciation is extended to the Department of Accounting and Business Law and the College of Business Administration at The University of Tennessee, Knoxville for the financial support provided during my doctoral studies.

Special recognition is extended to my wife, Connie, for her understanding, encouragement, and valuable assistance. Lastly, a word of thanks to my parents for their inspiration and unselfish support.

ABSTRACT

A computer simulation tool was developed to assist an auditor in the planning of compliance testing procedures for transaction cycles or subcycles. The simulation tool was designed to facilitate three specific aspects of an auditor's task:

1. Evaluating the overall reliability of the cycle with respect to specific errors.
2. Establishing acceptable compliance levels for individual controls in the cycle.
3. Appraising the relative efficiency and effectiveness of alternative compliance testing procedures contemplated for the cycle.

Based on auditor specifications for a particular transaction cycle, the simulation constructs a computer model of the cycle's internal control system and allows contemplated alternative compliance testing procedures to be undertaken. The simulation consists of two operational phases. Phase one of the simulation monitors the processing of a specified number of transactions, develops and reports reliability statistics for the various elements of the system. The principal statistics generated for each system element include: the actual error occurrence rate, the final balance reliability, and the probability that an error will be detected and corrected by the system once it has occurred.

Phase two of the simulation allows the transaction processing to be sampled by alternative compliance testing procedures. The compliance

testing procedures which may be evaluated include three traditional sampling approaches (fixed sampling, dollar unit sampling, and sequential sampling) and four EDP approaches (auditing around the computer, parallel simulation, integrated test facility, and test data). Phase two of the simulation monitors the transaction sampling activity of each procedure, develops and reports the following three measures of effectiveness for each procedure: the probability of no sampling error, the probability of overauditing, and the probability of underauditing.

The usefulness of the simulation tool was demonstrated by application to a typical, computer-based payroll cycle. The application indicates that the simulation can assist an auditor by providing a basis for screening a set of potential compliance testing procedures. The principal advantages are (1) the simulation tool is interactive and does not require computer expertise to employ and (2) the simulation tool provides an environment for investigating internal control relationships and the efficiency and effectiveness of procedures before audit resources are committed.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

A careful review of the internal control elements of a client's accounting system has been an integral part of the financial auditing process for many years. Recent developments, however, have caused independent auditors to attach increased importance to this audit step. These developments include the Foreign Corrupt Practices Act of 1977, the recommendations of the Commission on Auditors' Responsibilities (AICPA, 1978), a number of promulgated professional standards,[1] the additional risks associated with auditing computer-based accounting systems, and the rising cost of performing audit procedures.

I. AUDITOR'S EVALUATION OF INTERNAL CONTROL

A proper study and evaluation of internal control is required by the second standard of field work and further described in Section 320 of Statements on Auditing Standards (SAS's) (AICPA, 1981). The SAS's identify two distinct phases of the study and evaluation of internal control--a system review phase and a compliance testing phase. In the system review phase the overall system is first divided into major segments or transaction cycles. The auditor then makes a preliminary evaluation of internal control strengths and weaknesses in each cycle, establishes the potential reliance that might be placed on these

---

[1]See <u>SAS No. 16</u> (AICPA, 1981), <u>SAS No. 12</u> (AICPA, 1981), and <u>SAS No. 30</u> (AICPA, 1981).

controls, and develops a tentative audit plan for each cycle. In most cases, this tentative plan consists of a combination of compliance and substantive testing procedures which presumes the potential reliance established for key controls is warranted.

The compliance testing phase follows to verify that controls for which reliance is planned are functioning properly. If compliance testing results indicate that the planned degree of reliance for certain controls is unwarranted, the tentative audit plan must be revised. The required adjustments typically involve an expansion of related substantive testing. Thus, the scope of substantive testing required is inversely related to the quality of internal controls. Since compliance testing procedures are often less costly to perform than the substitute substantive testing procedures, the auditor's decisions regarding the proper mix of compliance and substantive testing procedures are a major determinant of overall audit costs.

Section 320 outlines a logical approach to the evaluation of internal controls in each transaction cycle. This recommended approach is summarized by the following steps (AICPA, 1981, 320.65):

1. Consider the types of errors and irregularities that could occur.
2. Identify the control procedures that should prevent such errors and irregularities.
3. Determine whether the necessary control procedures are being followed.
4. Evaluate any weaknesses in existing control procedures.

II. ROLE OF AUDITOR JUDGMENT

The auditor's study and evaluation of internal control culminates in judgments regarding the effectiveness of key controls in each transaction cycle. These conclusions are based on audit evidence from a number of sources, which typically include inquiries and observations made by the auditor, compliance testing procedures, and compliance error analysis. Since many elements of internal control (such as segregation of duties) are not amenable to objective measurement, and because one type of audit evidence can often substitute for another, the process of evaluating internal control and finding the proper mix of audit procedures for the audit draws substantially upon the auditor's professional judgment.

This research focuses on the task of planning compliance testing procedures. In planning a strategy for compliance testing the auditor must make a number of important decisions. Two of the most difficult of these decisions are: (1) the choice of appropriate compliance procedures for achieving audit objectives, and (2) the choice of proper sample sizes.

The process of choosing appropriate compliance procedures requires the auditor to evaluate the efficiency and effectiveness characteristics of alternative compliance procedures. For example, in a computerized environment alternatives available for selection include electronic data processing (EDP) techniques and various compliance testing sampling approaches including fixed, sequential, and dollar unit sampling. The efficiency of a compliance procedure refers to the cost of performing the procedure and the relationship of this cost to the cost of substantive procedures potentially avoided. The effectiveness of a compliance procedure refers to the likelihood that the procedure will detect suspected compliance deviations. This likelihood must be related to the risk of and penalty associated with failure to detect these deviations. At the present time, auditors must rely upon professional judgment to accomplish this task of choosing appropriate compliance testing procedures.

To determine the proper sample size for a particular compliance procedure, the auditor must make at least three critical judgments. These include establishing: (1) the estimated error occurrence rate for the control being tested, (2) the maximum acceptable error rate consistent with the planned reliance for the control, and (3) the risk of underauditing and the risk of overauditing the auditor is willing to assume. Making these judgments requires that the auditor have a clear understanding of all internal control relationships present in the cycle. For example, the auditor must know the sensitivity of overall cycle reliability for a particular error to small changes in exception rates for related controls.

The evaluation of internal controls in transaction cycles consisting of only a small number of processing and control steps usually presents little difficulty to auditors. Unfortunately, however, transaction cycles often involve numerous processing and control steps and intricate control relationships (such as redundant controls and repeated feedback loops). Gaining the requisite understanding of control relationships in these complex systems can become a formidable task. The task becomes even less tractable for systems in which systematic errors or collusion are suspected.

The problem of system complexity is of particular concern for computer-based accounting systems. EDP poses an unfamiliar audit environment in which traditional audit documentation is often missing. In this environment processing and control steps once performed by several individuals may now be concentrated into one or more computer programs. Indeed, advanced systems are capable of totally processing transactions without human intervention.

Clearly, objective approaches are needed to assist auditors in evaluating internal controls in transaction cycles exhibiting such configurational and technological complexities.

III. OVERVIEW OF THE RESEARCH

The objective of this research study was to develop a simulation tool which formalizes many of the judgmental decisions inherent in the task of planning compliance testing procedures for transaction cycles or subcycles. The simulation tool was designed to provide assistance in three specific aspects of this task: (1) establishing the overall reliability with respect to specific errors for the cycle, (2) establishing acceptable compliance levels for individual controls in the cycle, and (3) evaluating the efficiency and effectiveness of alternative compliance testing procedures.

The simulation tool developed allows the auditor to construct a computer model of the internal controls affecting a specific transaction cycle or subcycle, and of alternative compliance testing procedures contemplated for the cycle. Specifications for both the internal control model and the compliance procedures are made by the auditor interactively from a computer terminal. The simulation tool essentially provides a risk-free environment in which the auditor can explore internal control relationships and the probable outcome of compliance strategies before audit resources are committed.

The internal control model developed for each application represents the internal control system as a network of processing steps and control steps through which simulated transactions pass. As each transaction is processed, the simulation determines if any of the specified errors or control exceptions at each step will occur, and if the transaction will be sampled by compliance procedures applied at each step. The simulation generates errors and control exceptions randomly, allows irregularities to occur systematically, and allows collusion between processing and control steps. When the simulated transaction processing is complete, the simulation analyzes the processing history of the simulated transactions and develops a variety of reliability statistics.

The simulation tool allows the auditor to compare the efficiency and effectiveness of seven different EDP and traditional approaches to compliance testing, in an internal control environment specified by the auditor. EDP approaches implemented include: (1) auditing around the computer, (2) parallel simulation, (3) integrated test facility, and (4) test data. Traditional approaches include: (5) fixed, (6) sequential, and (7) dollar unit sampling. A measure of the probability of no sampling error, the probability of overauditing and the probability of underauditing is developed for each procedure.

The usefulness of the simulation tool was demonstrated by its application to a typical, computer-based payroll cycle. A series of simulation experiments was performed to observe the sensitivity of internal control reliability to changes in assumptions regarding error rates, exception rates, and collusion between processing and control steps. A second series of experiments was performed to appraise the relative efficiency and effectiveness of compliance testing procedures of each of the seven types.

IV. CONTRIBUTIONS OF THE RESEARCH

This research presents a unique approach to the auditor's study and evaluation of internal control. The study makes three significant contributions to the body of literature in this area.

First, the study is the first to offer a framework for appraising the effectiveness of alternative compliance testing procedures for specific audit situations. In a more general sense, the study is the first to provide a basis for comparing the seven compliance testing approaches listed previously.

Secondly, the study marks the first effort to address the impact of collusion on internal control reliability. This overcomes a major criticism of previous approaches which have assumed independent and stochastic errors and control exceptions.

Finally, the study provides the first internal control simulation tool which is generalizable to different audit applications. The model can be adapted to a particular audit situation simply by changing input specifications, without knowledge of computer programming languages. Simulation approaches in all previous studies were programmed for a single application and required programming expertise to employ.

V. ORGANIZATION OF THE STUDY

This research study consists of five chapters. The five chapters are organized as follows:

Chapter I--Introduction

Chapter II--Literature Review

Chapter III--Research Methodology

Chapter IV--Results

Chapter V--Conclusions

CHAPTER II

LITERATURE REVIEW

As stated in Chapter I, this study proposed a simulation approach for evaluating internal control and for appraising selected EDP and traditional approaches for compliance testing. To provide a basis for this endeavor, a review of prior research related to internal control evaluation, EDP auditing, and statistical sampling in auditing was conducted. This chapter summarizes previous studies that have had a major influence on this study.

I. OBJECTIVE APPROACHES TO INTERNAL CONTROL EVALUATION

Objective approaches to internal control evaluation have been offered by Yu and Neter (1973), Cushing (1974), Burns and Loebbecke (1975), Hamlen (1980), and Cash, Bailey, and Whinston (1977b). The first four studies focus on reliability aspects of internal control. The internal control system is generally viewed as a sequence of transaction processing steps in which errors stochastically occur. Each model generates a measure of internal control reliability of use to the auditor.

The models developed by Yu and Neter (1973) and Cushing (1974) are based on the mathematics of reliability engineering and Markov processes, respectively. Both models measure reliability in terms of the probability of the system making and failing to correct an error.

Cushing's model also represents various elements of system cost. Yu and Neter's model treats the accounting system as a Markov process and determines system reliability by a sequence of matrix transformations.

In an extension of Cushing's (1974) treatment, Bodnar (1975) cites a number of problems associated with the application of reliability theory to the internal control environment. Bodnar's central theme is that internal control systems involve a human element and that humans cannot be expected to behave as machines. Hence, a straightforward extension of reliability concepts to human performance may not be appropriate. A second major difficulty concerns the statistical independence of operating elements which reliability theory assumes. This assumption effectively rules out collusion in the internal control environment. Since collusion is by far the biggest threat to internal control systems (Carmichael, 1970, p. 238), this assumption embodies a most unrealistic simplification. The questions raised by Bodnar apply equally to each of the internal control reliability models discussed.

These mathematical approaches are limited in two other respects. First, neither model accomodates repeated feedback loops, a control mechanism common to many internal control systems. Second, as system complexity rises, the mathematical formulations required quickly become prohibitively difficult.

Burns and Loebbecke (1975) propose a simulation methodology for evaluating internal control and for establishing acceptable compliance levels in complex systems. System reliability is expressed as the probability distribution of aggregate dollar errors the system might produce in a final account balance. The simulation allows the auditor to observe the sensitivity of aggregate dollar errors to varying compliance level assumptions for individual controls. The principal advantage of simulation is that more intricate internal control relationships can be modeled with simulation than can be represented by mathematical formulations. A particular advantage of Burns and Loebbecke's model is the provision of a measure of reliability in terms of expected dollar errors in an account balance. A major drawback is that the simulation must be reprogrammed for each specific application, which requires considerable programming expertise.

The usefulness of a simulation decision aid, similar to that suggested by Burns and Loebbecke (1975), was investigated in a study by Weber (1978). In Weber's study forty practicing auditors evaluated the overall system reliability of a hypothetical inventory system. Weber found that auditors using the simulation aid: (1) made more accurate decisions, (2) had more confidence in their decisions, and (3) required less time, than those in a control group who did not use the simulation aid. Weber also noted that development of the simulation aid required extensive computer programming and that, consequently, a generalized audit simulation language was a much needed refinement.

Hamlen (1980) presents an integer programming model for internal control design and evaluation. The model seeks to minimize system cost subject to error reduction goals set by management for designated error types. The major difficulty with this approach is the accelerated rate of growth of the constraint set for even small increases in the number of processes.

In the final study, Cash, Bailey, and Whinston (1977b) propose a network data base approach to the formal description, review, and evaluation of internal control systems. The model developed provides a computerized permanent audit file for organizing and retrieving data about the internal control system. This mechanism facilitates the objective evaluation of internal control elements, such as segregation of duties, from an overall system perspective. The model, however, does not address the reliability aspects of individual system components.

Summary

The only feasible approach for objectively evaluating the reliability of complex internal control systems appears to be simulation. However, internal control simulations in previous studies were for single applications only and required considerable programming expertise to develop. A generalized simulation approach is needed.

II. EDP AUDITING

The advent of computer technology has had a profound impact upon the audit function. Auditors of computer-based accounting systems are challenged with an unfamiliar audit environment void of traditional audit trails yet filled with new risks and exposures. A major concern of many auditors is the loss of traditional internal control procedures implied by the EDP environment. Procedures once performed by a number of individuals may now be accomplished by computer software. This concentration of processing and control steps denies the internal control protection provided by separation of duties in manual systems.

SAS No. 3 (AICPA, 1981) discusses the effect of EDP on the auditor's study and evaluation of internal control. This pronouncement identifies two basic types of EDP control procedures--general controls and application controls. General controls relate to the computer facility and affect all EDP activities. Application controls relate to specific application areas (such as payroll) and affect only those EDP tasks performed in that application. The approach recommended in SAS No. 3 for evaluating EDP controls is basically the same as the approach recommended in SAS No. 1 for evaluating manual controls.

Fortunately, computer technology has also made measures available for countering these new audit risks and exposures. Descriptions of computer-assisted techniques for the audit and control of computer systems abound in the literature. State of the art surveys have been conducted by the Institute of Internal Auditors (Stanford Research Institute, 1977), the American Institute of Certified Public Accountants (AICPA, 1979), Cash, Bailey, and Whinston (1977a), Mair, Wood, and Davis (1976), Burch and Sardinas (1978), and others. The techniques identified are generally classified into two groups--techniques to verify processing controls (compliance testing procedures) and techniques to verify the results of processing (substantive testing procedures). Table 1 presents a compilation of the different techniques included in the above surveys.

Table 1 illustrates that many techniques have been developed for the collection of audit evidence in an EDP environment. In fact, as pointed out by Weber (1982, p. 399), the auditor's problem is certainly not a shortage of computer audit techniques. The auditor's problem is

TABLE 1

SURVEY OF EDP AUDIT TECHNIQUES

Technique	Selection Criteria Not Satisfied
*Around the computer	All Satisfied
*Test Data	All Satisfied
*Integrated Test Facility	All Satisfied
Tagging and Tracing	A,B
Concurrent Processing	A
*Parallel Simulation	All Satisfied
Controlled Processing or Reprocessing	C
Program Code Checking	B
Flowchart Verification	B
Mapping	B
Comparison	C
Confirmation	C
Edit and Reasonableness Tests	C
Software or Hardware Monitors	A,B,C

Criteria for Selection

A. Applicable to existing system.

B. Requires only a minimum level of EDP expertise.

C. Techniques for compliance testing of application controls.

*Denotes techniques considered in this research.

how to choose the best technique (or set of techniques) for a given audit situation. At present this determination requires auditor judgment for two primary reasons. First, the cost effectiveness characteristics of the various techniques are situation-dependent and are at best difficult to measure. Secondly, no professional guidance is available to the auditor for making this critical audit decision.

In addressing this void, this research considers four EDP auditing techniques: auditing around the computer, test data, integrated test facility, and parallel simulation. These are denoted by asterisks in Table 1 and were selected in accordance with the following three criteria:

(1) The technique must be applicable to an existing system, i.e., it does not require auditor involvement during system development.

(2) The technique must require only a minimum level of EDP expertise.

(3) The technique must be for compliance testing of application controls.

The first two criteria were established to eliminate techniques that might be unfeasible for a broad range of audit situations. Because most existing EDP systems were designed without auditor participation, many system features desirable from an audit standpoint (such as tagging, tracing, or hardware and software monitors) are often missing in existing systems. Furthermore, most audit teams do not possess the high level of computer expertise required by many EDP auditing techniques (such as program code checking, flowchart verification, or mapping). The final criterion was included to exclude techniques primarily designed for substantive testing (such as comparison, confirmation, or edit and reasonableness tests) or primarily used for testing general EDP controls. Table 1 indicates the basis for eliminating each of the techniques not included in the study.

Summary

Many techniques are currently available to the auditor for auditing EDP systems. A major problem the auditor faces is how to evaluate the relative cost effectiveness of the various techniques for specific audit applications.

III. STATISTICAL SAMPLING IN AUDITING

Because of its many attractive features, the use of statistical sampling in auditing has become a routine practice in recent years. Authoritative guidance to the use of statistical sampling in auditing is provided in Section 320 of SAS (AICPA, 1981). Numerous interpretations of the statistical sampling aspects of Section 320 have appeared in the literature. These have made significant contributions to clarifying the role of statistical sampling in the audit process, the risks associated with its use, and the relationship of these risks to ultimate audit risk. Representative of these are works by Smith (1972), Elliot and Rogers (1972), Kinney (1975), Loebbecke and Neter (1975), Arkin (1976), Roberts (1978), and Warren (1979).

Statistical sampling is typically incorporated into both the compliance testing (attribute sampling) phase and the substantive testing (variables sampling) phase of the audit. This research focuses on statistical sampling procedures for compliance testing (attribute methods). Attribute methods can be generally classified as fixed sample size plans, sequential (also called stop and go) plans, or combined attributes-variables (also called dollar unit or sampling proportional to size) plans. Although articles describing the mechanics of attribute methods are plentiful, research comparing their relative effectiveness is scarce.

Maxim, Cullen, and Cook (1976) outline a cost model for computing the expected cost of sequential sampling plans in specific applications. The model developed incorporates direct and indirect costs of sampling and is quite complex. The authors demonstrate that sequential plans are generally superior where the fixed costs of sampling are relatively low and error rates are either much lower or much higher than anticipated.

Combined attributes-variables (CAV) sampling combines many features of attribute and variables methods. Introduction of the approach (see Anderson and Teitlebaum (1973), Goodfellow, Loebbecke, and Neter (1974)) has launched a stream of research studies in recent years. These studies, for the most part, investigate the behavior of various statistical estimators in accounting populations which have pre-specified error characteristics. Their primary focus is on variables sampling issues. Representative of these are efforts by Neter and Loebbecke (1975), Reneau (1978), and Ramage, Krieger, and Spero (1979).

Summary

Studies describing the application of statistical sampling to auditing are in great supply. However, very few of these provide guidance for evaluating alternative attribute methods. No basis for comparing the relative efficiency and effectiveness of fixed sampling plans, sequential plans, and CAV plans in specific applications has been proposed.

CHAPTER III

RESEARCH METHODOLOGY

To achieve the objectives of this research an audit simulation tool was developed. This chapter describes the design and operation of the simulation tool (simulation) and briefly discusses steps taken for its validation.

I. SIMULATION OVERVIEW

The simulation consists of a package of computer routines coded in the PASCAL programming language. Based on auditor specifications for a particular transaction cycle, the simulation first constructs a computer model of the internal controls affecting the cycle (simulated internal control system) and the alternative compliance testing procedures (simulated compliance procedures) contemplated for the cycle. The simulation then causes a number of transactions to be processed by the internal control system and to be sampled by the compliance procedures. This simulated transaction activity is monitored and analyzed to develop the simulation results.

The simulation consists of two independent phases of operation. Phase one of the simulation generates reliability statistics for the internal control system. The purpose of this reliability data is to assist the auditor in assessing the reliability of the processing and control elements comprising the cycle. Phase two of the simulation develops effectiveness measures for each of the compliance procedures.

The purpose of these measures is to assist the auditor in formulating a compliance testing strategy.

Figure 1 summarizes the general steps of the simulation as applied to a particular transaction cycle. In accordance with SAS Section 320 (AICPA, 1981, 320.65) the auditor (1) is assumed to have considered the errors and irregularities that could occur in the cycle, (2) to have identified key controls that should prevent or detect these errors and irregularities, and (3) to have tentatively selected a set of alternative compliance procedures for verification of the key controls. Additionally, a flowchart of the cycle's internal control system has already been developed. The auditor begins the simulation by formulating input specifications for the internal control system, using as a basis the flowchart of the internal control system. Next, the auditor formulates input specifications for each of the alternative compliance procedures under consideration. When all input specifications have been prepared the auditor submits these to the simulation. The internal control system and compliance procedures are thus defined in terms the simulation can interpret.

At this point the simulation accepts the auditor specifications and constructs a computer model of the internal control system and the alternative compliance procedures. Phase one of the simulation causes the processing of a number of transactions by the internal control system. This simulated transaction activity is monitored and the processing results are used to develop reliability statistics for the various elements of the internal control system. The simulation outputs this reliability data as phase one results.

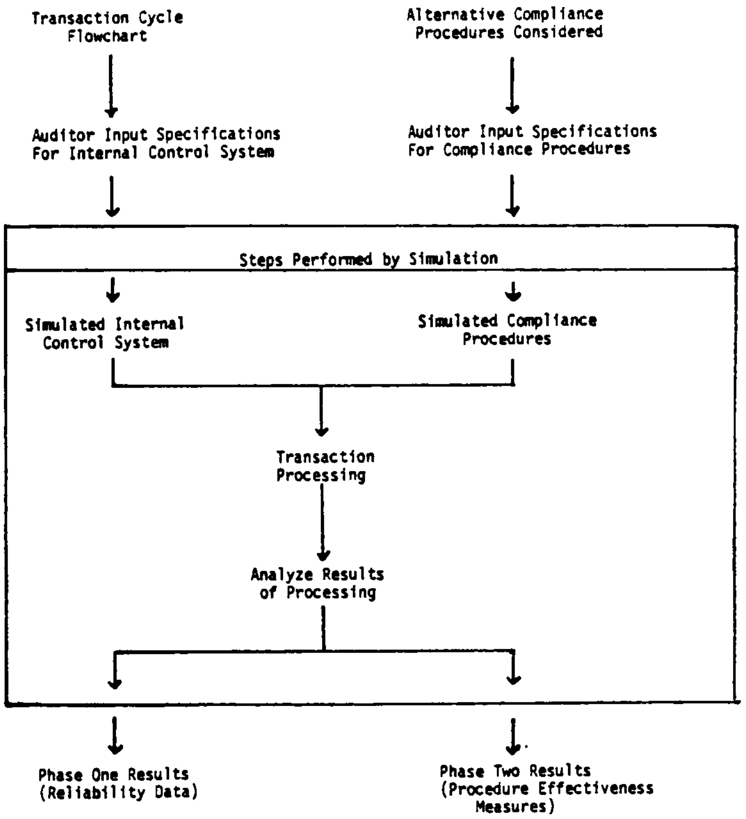


Figure 1. Overview of Simulation.

Figure 2 presents a sample phase one output for a processing (step 7) and a control (step 3) step. This sample output is provided at this point merely to acquaint the reader with the nature of phase one simulation results. For this run, processing step 7 exhibited an actual error rate of 10.19% and a final balance reliability of 97.59%. The final balance reliability implies that less than 3% of all transactions would be expected to ultimately have an error in step 7 associated with it. Furthermore, 51 errors for step 7 occurred for a total error amount of $2646.90 and 39 were corrected by the system. Of the 39 errors corrected by the system, 36 were detected by controls and subsequently corrected while 3 were corrected via a reprocessing step. Similarly, 65 exceptions for control step 3 yielded an actual exception rate of 13% and a final balance reliability of 91.19%. Control 3 detected 20 of 21 error occurrences of step 1 and 65 of 77 error occurrences of step 2. Phase one output elements are further discussed in a subsequent section.

Phase two of the simulation expands this simulated transaction processing by activating the compliance procedures. The transaction sampling activity of each procedure is monitored over multiple runs of the simulation and three measures of effectiveness are developed for each procedure. These measures are the probability of no sampling error, the probability of overauditing, and the probability of underauditing. These probabilities are calculated as the percentage of all simulation runs for which the sample conclusion regarding the reliability of a system element under examination would lead to no sampling error, overauditing, or underauditing, respectively. For example, overauditing (underauditing) occurs where the sample conclusion for a

```
*************************************************

   *** RESULTS FOR PHASE ONE ***

**************************************************


*** RESULTS FOR PROCESSING STEPS FOLLOW ***

**********

 STEPNO=    7 NAME=  TX CODING ERR - HRS OR RATES
 TOT ACT= 500 ACT ERR RATE= 0.1019
 CRIT MAX FB OCC=  25
 ERRORS OCCURRED=  51 SYS DET=  39 ERRORS IN FB=  12
 CORR VIA REPROC=   3 DET VIA CONTROLS=  36
 TOT ERR AMT=    2646.90 FBERRAMT=      636.37
 SYS REL GIVEN ERR OCC= 0.7647 SYS FIN BAL REL= 0.9759

**********



 *** RESULTS FOR CONTROL STEPS FOLLOW ***

**********

 STEPNO=    3 NAME=  FMN VERIF
 NO OF EXC=  65 TOT ACT= 500 ACT EXC RATE= 0.1300
 EXCAMT=      881.13
 FIN BAL OCC=  44 FIN BAL REL= 0.9119
 CRIT MAX EXC=  90

 CONTROL DET  20 OF  21 OCC OF ERROR NO   1
 ERROR NAME=  INV EMP
 ERR AMT DET=    10222.08 PER CENT OF TOT ERR= 0.9485

 CONTROL DET  65 OF  77 OCC OF ERROR NO   2
 ERROR NAME=  HRS REC ERR
 ERR AMT DET=     1845.61 PER CENT OF TOT ERR= 0.8497

**********
```

Figure 2. Sample Phase One Results.

given procedure indicates that the reliability of a system element is unacceptable (acceptable) while the actual reliability is acceptable (unacceptable) for the run. These effectiveness measures are provided for each procedure and output as phase two results.

II. SIMULATION DESIGN

In this section the major features of the simulation's input requirements, transaction processing activity, and results are addressed in sequence.

Input Requirements

The simulation requires three categories of auditor specifications. The three categories define the scope of the simulation activity, the features of the internal control system to be simulated, and the characteristics of the compliance procedures to be evaluated, respectively. In most cases, all three categories of auditor specifications can be obtained from current or previous year audit working papers. These specifications can be entered by the auditor interactively from a computer terminal, or can be read from a pre-existing data file.

The first category of auditor specifications describes the scope of the simulated transaction activity. A simulation experiment consists of a number of simulation runs. Each simulation run, in turn, involves the processing of a number of transactions. Consequently, the auditor must specify:

1. The phase of operation desired (phase one or two).
2. The number of transactions to be processed in each run.

3. The transaction dollar amount distribution type and parameters.
4. The number of simulation runs to be made (for phase two only).

Distribution types implemented include the normal distribution (parameters are mean, standard deviation, minimum value, and maximum value) and the uniform distribution (parameters are minimum and maximum value).

The simulation also requires input related to the random number generator to be used in the simulation. Each of the stochastic processes incorporated in the simulation is driven by a random number stream produced by a random number generator. Hence, the simulation results for a given run are somewhat dependent upon the particular sequence of random numbers utilized for the run. To compensate for this potential bias, the simulation provides a means of altering the random number sequence utilized for replications of a given run. The auditor controls the random numbers for each run by specifying a start position on a single random number sequence to be used for the run. Hence, although only a single random number sequence is employed, different segments of the sequence may be utilized for each run of the simulation.

The second category of auditor specifications defines the internal control system to be simulated. The simulation essentially represents the internal control system as a network of processing, control, and branch steps. Transaction processing activity (described in a later section) refers to the flow of simulated transactions through this network.

As the current transaction passes through a processing step, a specified error and/or irregularity may occur and become associated with the transaction. The simulation allows errors to occur randomly at specified rates. The simulation also allows irregularities to occur systematically with a specified cyclic pattern (as every 20th transaction, for example), or when an error in one or more colluding steps has occurred for the transaction. If a processing step is performed and no error occurs, the simulation automatically corrects previous errors or irregularities which may have occurred in the same step for the current transaction. Processing steps (reprocessing steps) may also correct previous errors or irregularities in other specified steps for the current transaction.

Similarly, as the current transaction passes through a control step, a control exception may occur and become associated with the transaction. The simulation allows control exceptions to occur with or without collusion. Exceptions for control steps without collusion can occur randomly at specified rates. The simulation also allows exceptions for control steps with collusion to occur at a specified higher rate whenever an error has occurred in a specified colluding step. Each control step is capable of detecting errors in one or more processing steps. When an error is detected by a control step a designated branch step is automatically activated (i.e., a branch will occur).

Branch steps allow branching to occur in the processing sequence for a transaction. Branching typically is needed after a control step has detected an error in the current transaction. When branching occurs, the current transaction is directed out of the normal processing sequence, usually to a processing step for correction of an error. For a given branch step, branching occurs only if the branch step has been activated by a control step for the current transaction. Otherwise, no branching occurs and the normal processing sequence is followed.

Figure 3 delineates the auditor specifications required for each processing, control, and branch step. Taken together, the step specifications comprehensively define the internal control system to be simulated. The maximum acceptable final balance error rate represents the threshold level of reliability for a given step that is consistent with the planned reliance on internal control. Thus, an actual rate above this level would cause the auditor to adjust his planned reliance. This maximum acceptable rate is used in phase two of the simulation only.

Figure 4 presents excerpts from a computer listing produced by the simulation that illustrates typical input specifications for each step type. To clarify, step 1 (STEPID=1) is a processing step (STEPTYPE=P) labeled Invalid Employee. The next step is step 2 (NXTSTEP=2), the estimated error rate is 5% with no irregularity pattern (IRRFLAG=N), and the tentative (the ultimate value is dependent on phase one findings) maximum acceptable final balance error rate is 1%. Error amounts are normally distributed (DTYPE=N) with a mean of \$500, standard deviation of \$50, minimum of \$300, and maximum of \$700. Similarly, step 5 is a processing step which serves to correct or reprocess errors in steps 1 and 2. Step 3, labeled Foreman Verification, is a control step (STEPTYPE=C) for errors in steps 1 and 2. If an error is detected branch step 4 is activated (BRFLGSTP=4). Finally, step 4 is a branch step which causes a branch to step 5 if activated, else the next step

For Each Processing Step:

1. Step number and descriptive name.
2. Estimated error occurrence rate.
3. Cyclic pattern (if irregularity is present).
4. Error amount distribution type and parameters.
5. Step numbers this step can correct (if any).
6. Maximum acceptable final balance error rate.
7. Step number of next step.

For Each Control Step:

1. Step number and descriptive name.
2. Estimated exception rate.
3. Colluding step and collusion exception rate (if collusion is present).
4. Step numbers of processing steps controlled.
5. Maximum acceptable final balance exception rate.
6. Next step if no error in controlled step is detected.
7. Branch step to be activated if error is detected.

For Each Branch Step:

1. Step number and descriptive name.
2. Next step if branch occurs.
3. Next step if no branch occurs.

Figure 3. Auditor Specifications for Internal Control System.

```
*********************************************************

STEPID=   1 STEPTYPE= P STEPNAME=  INV EMP

NXTSTEP=   2 ERRATE= 0.0500 LINK=   2 IRRFLAG= N
CRIT MAX FIN BAL OCC= 0.0100
DTYPE= N MEAN= 500.00 STDEV=  50.00 MIN= 300.00 MAX= 700.00

*********************************************************

STEPID=   5 STEPTYPE= P STEPNAME=  FMN CORR OF TIME CARD ERR

NXTSTEP=   6 ERRATE= 0.1000 LINK=   6 IRRFLAG= N
CRIT MAX FIN BAL OCC= 0.1000
NON-MONETARY
STEPS REPROCESSED ARE :      1     2

*********************************************************

*********************************************************

STEPID=   3 STEPTYPE= C STEPNAME=  FMN VERIF

ERRORS CONTROLLED ARE:      1     2
NEXTSTEP=   4 BRFLGSTP=   4
LINK=  12 EXCRATE= 0.1500 COLUFLG= N
CRIT MAX FIN BAL OCC= 0.1200

*********************************************************

*************************************************

STEPID=   4 STEPTYPE= B STEPNAME=  BR FOR TIME REC CORR

NO BR STEPNO=   6 BR TO STEPNO=   5

*************************************************
```

Figure 4. Typical Step Specifications.

is step 6. The link attribute (LINK=) for each step is a list pointer and has no significance to the user.

The final category of auditor specifications characterizes the alternative compliance procedures to be evaluated. Seven different EDP and traditional approaches (procedure types) to compliance testing have been implemented:

1. Auditing around the computer.
2. Test data.
3. Integrated test facility (ITF).
4. Parallel simulation.
5. Fixed sampling.
6. Sequential sampling.
7. Dollar unit sampling.

Before auditor specifications for individual procedure types are detailed, the manner in which the various procedure types are implemented is briefly discussed.

Generally, procedures are implemented as mechanisms which cause simulated transactions to be sampled as they flow through the internal control system. If a sampled transaction contains a deviation (error, irregularity, or exception) of a type (step) a particular procedure is designed to find, the deviation is considered to be detected. Sample conclusions for the procedure are determined, for each deviation type the procedure can detect, by comparing the number of deviations detected to a specified maximum acceptable number of sample occurrences.

Auditing around the computer, parallel simulation, and test data procedures diverge significantly from this pattern and are treated separately. The remaining procedure types are largely similar and vary principally in the manner in which transactions are selected from the simulated transaction stream. Transactions are randomly selected from the stream for fixed sampling and sequential sampling procedures (however, multiple samples are drawn). For dollar unit sampling procedures, transaction selection is random with the probability of selection proportional to the size of the transaction. Selection for ITF procedures can be random or systematic, i.e., following a specified cyclic pattern.

Auditing around the computer procedures do not directly examine computer controls but evaluate computer controls indirectly through a comparison of pertinent computer input and related output. Accordingly, in this simulation around the computer procedures sample an input summary step and an output summary step which are included in the internal control model for this purpose. An input (output) summary step registers an error only if any of a specified set of errors or irregularities are present in computer input (output) for the current transaction. For a sampled transaction one of the following three error detection criteria may be specified:

1. An error occurs if an error is present in the output summary step.
2. An error occurs if the input summary status and the output summary status are not the same.
3. An error occurs if an error is present in both the input and output summary steps.

Implementation of parallel simulation procedures differs from other procedure types in two primary respects. First, transaction selection, although random, occurs over a limited range of transactions. Second, sample conclusions are derived through a two step process. In the first step the simulation calculates the absolute dollar difference between a measure of the recorded book balance for the account in question and a simulated book balance for the account. In this application, both measures are determined by the simulation. The recorded book balance is based on simulated transaction processing results, while the simulated book balance is estimated from the parameters of the transaction amount distribution. In the second step the simulation compares this absolute dollar difference to an auditor-specified maximum acceptable dollar level to obtain the sample conclusion.

Implementation of test data procedures differs widely from other procedures in the manner transactions are handled. Unlike the other procedure types, test data procedures do not sample from the simulated transaction stream. This is because the test data approach typically utilizes transaction data created by the auditor to test specific features of a computer program. For this procedure the simulation assembles a set of test data transactions according to auditor specifications. This test data set may contain transactions with errors initialized and/or error-free transactions. The transactions test data set is processed through the simulated internal control system separately after transactions for all other procedures.

Figure 5 summarizes the required auditor specifications for the seven procedure types. The simulation allows multiple procedures of each type in a given experiment.

As noted, the simulation accepts input from a computer terminal or from a pre-existing disk data file. Two modes of input are available for terminal input--prompt mode and no-prompt mode. If prompt mode is selected the simulation prompts the user for each element of required information. For example, in prompt mode the user is instructed when to enter the next procedure type, name, sample size, etc. In no-prompt mode only minimal prompts are provided for the user.

Regardless of the input mode used, the input specifications are first edited for syntax errors. For example, if the auditor inadvertently enters a real value in place of an integer value, a syntax error occurs. The simulation flags syntax errors by displaying a diagnostic error message and assigning a default value to the variable. After all auditor specifications are completed, the simulation displays these inputs for the auditor to review and provides an opportunity for the auditor to correct erroneous entries.

Transaction Processing

At this point all input specifications necessary for the simulation have been entered and edited for syntax errors. These inputs are stored by the simulation and used to develop a computer model of the internal control system and of alternative compliance procedures.

Before transaction processing begins the simulation identifies (randomly or systematically, as appropriate) the transaction numbers

Required For All Procedure Types:

1. Procedure number, type of procedure, and descriptive name.
2. Step number of all deviations the procedure can detect.
3. The critical maximum number of sample occurrences (or materiality amount for parallel simulation procedures) for each deviation type the procedure can detect.
4. Sample size (not applicable to test data procedures, see below).

Additional Requirements:

<u>For Parallel Simulation</u>

-Range of transactions to be sampled.

<u>For ITF</u>

-Transaction sampling method (random or cyclic) and cyclic pattern if cyclic (for example, every n^{th} transaction).

<u>For Test Data</u>

-Number of transactions with each deviation type to be initialized.

-Number of transactions to be initialized without errors.

<u>For Auditing Around the Computer</u>

-Input and output summary step numbers.

-Decision criteria for error detection.

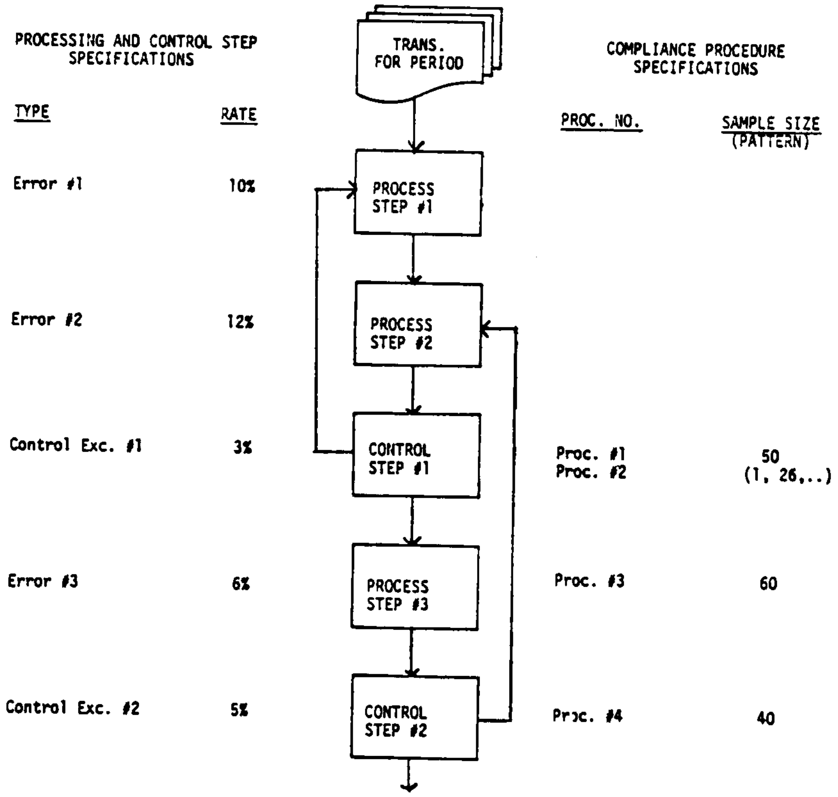
Figure 5. Auditor Specifications for Compliance Procedures.

to be sampled by each compliance sampling procedure. The transaction numbers to be sampled by each procedure are sorted in ascending order and stored for later use. Similarly, lists of transactions in which irregularities will occur are built for each processing step which involves an irregularity.

Each simulation run entails the processing of a number of transactions through the internal control system. This simulated transaction processing represents the actual transaction activity for the audit period. As a simulated transaction is processed it may be sampled by one or more compliance procedures. When processing (and sampling) for a transaction is completed, its processing and sampling results are stored and a new transaction is generated.

Figure 6 illustrates this simulated processing activity for a simple system. The system consists of three processing steps and two control steps, and four alternative compliance procedures to be evaluated. Abbreviated auditor specifications for each processing and control step and each compliance procedure also appear in Figure 6.

The abbreviated processing and control step specifications in Figure 6 are interpreted as follows. Error type #1 is associated with processing step 1 and has an occurrence rate of 10%. Likewise, errors #2 and #3 are associated with processing steps 2 and 3 and have occurrence rates of 12% and 6%, respectively. Furthermore, control step 1 controls for errors in processing step 1 (occurrences of error #1) and has an exception rate of 3%. When an error #1 is detected by control step 1 the current transaction is immediately returned to processing step 1. Similarly, control step 2 serves as a control for



Summary of Processing for Transaction #1

Transaction Number	Error Type #1	#2	#3	Compl. Exc. #1	#2	Sampled by Proc. #1	#2	#3	#4	Final Bal. Result
#1	No	Yes	No	No	Yes	No	Yes	No	No	Error #2

Figure 6. Summary of Transaction Processing.

errors in processing step 2. Note that no such control mechanism is present for processing step 3.

The abbreviated compliance procedure specifications in Figure 6 define four alternative procedures for the simulation. For purposes of clarity in this illustration the many detailed aspects of the seven different procedure types are ignored. The four procedures are simply viewed as sampling mechanisms applied at various steps in the internal control system. For example, procedures #1 and #2 are applied at control step 1 to detect occurrences of compliance exception #1. Procedure #1 collects a random sample of 50 transactions while procedure #2 utilizes a systematic sample of every 25th transaction. In a similar fashion, procedures #3 and #4 invoke sampling operations at processing step 3 and control step 2, respectively.

In order to demonstrate the transaction processing steps performed by the simulation, a walk-through of the processing for a typical transaction might be helpful. Transaction #1, representing the first economic event impacting the account balance under examination, enters the system and proceeds to processing step 1. The simulation randomly determines that no error occurs in processing step #1 for this transaction. Processing for the transaction then continues at processing step 2 where the simulation randomly determines that an error #2 occurs and becomes associated with the transaction. Next, the transaction proceeds to control step 1 where the simulation determines that no exception occurs. Following this pattern, for this transaction no error occurs at processing step 3 but a control exception occurs at control step 2.

By consulting the previously constructed sample lists for the respective procedures, the simulation determines that transaction #1 is not sampled by procedures #1, #3, or #4 but is sampled by procedure #2. This completes processing for transaction #1. The simulation stores the processing results for the transaction and generates a new transaction.

In summary, one processing error (error #2) and one control exception (exception #2) occurred for transaction #1 and the transaction was sampled by one procedure (procedure #2). Furthermore, since control step 2 was the only step capable of detecting error #2 and failed to do so, an occurrence of error #2 will appear in the final balance of the account under examination. If an exception had not occurred in control step 2, the occurrence of error #2 would have been detected and the transaction would have been routed to processing step 2 for additional processing. In this case, note that error #2 could again occur in processing step 2 and that upon leaving processing step 2 the transaction would be sequentially processed again by control step 1, processing step 3, and control step 2.

Simulation Results

As noted earlier, the simulation features two phases of operation and of results. Phase one of the simulation monitors the simulated processing of a number of transactions through the internal control system and uses the processing results to generate reliability data for the various system elements. Likewise, phase two of the simulation monitors the sample results of each of the alternative compliance procedures over repeated runs of the simulation to develop three effectiveness measures for each procedure.

Figure 7 presents the phase one simulation information developed for each processing and control step. This information is derived from the results of the transaction processing for a simulation run.

As a transaction is processed through the internal control system various errors, irregularities, and control exceptions may become associated with the transaction. Likewise, if certain of these deviations are detected and corrected by the system, they are dissociated from the transaction. Of course, only deviations associated with the transaction at the completion of processing impact the final balance under examination. The simulation maintains a system of counters to record the processing history of each transaction and to characterize the activity of each processing and control step. Phase one results are then generated by the simulation based on the final activity counts for a simulation run.

Figure 8 depicts the phase two simulation results developed for each compliance procedure included in the simulation. The simulation develops these results by measuring the accuracy of the sample results for each procedure over repeated runs of the simulation. For each run, the sample results for a procedure reveal whether the sample conclusion for the run would lead to underauditing, no sampling error, or over-auditing. This determination is made by comparing the sample conclusion as to the reliability of the system element in question to the actual reliability of the system element for the run. For example, if sampling

For Each Processing Step (Error Type):

1. Step number and descriptive name.
2. Total step activity and actual error rate.
3. Number of errors that occurred and dollar amount.
4. Number of errors detected by the system.
5. Number of errors not detected by the system and dollar amount.
6. Probability of the system detecting this error given its occurrence. Calculated as:

   (# of corrected errors ÷ # of error occurrences).

7. System final balance reliability with respect to this error. Calculated as:

   (1 - (# of final errors ÷ # of transactions)).

For Each Control Step (Exception Type):

1. Step number and descriptive name.
2. Step numbers (deviation types) the control can detect.
3. Total activity and number and dollar amount of detections made.
4. Number of exceptions, dollar amount, and actual exception rate.
5. Percent of total error amount detected by this control, for each deviation type detected by the control. Calculated as:

   (total error amount detected by this control ÷ total error amount for the deviation type).

Figure 7. Elements of Phase One Results.

For Each Procedure:

1. Procedure type and descriptive name.
2. Sample size or average sample size.
3. For each deviation the procedure can detect:
   a. Step number of deviation detected.
   b. Probability of no sampling error.
   c. Probability of overauditing.
   d. Probability of underauditing.

Where:

- Probability of no sampling error =

  (# of runs with sample results of no error
  ÷
  total # of runs performed)

- Probability of overauditing =

  (# of runs with sampling results of overauditing
  ÷
  total # of runs performed)

- Probability of underauditing =

  (# of runs with sample results of underauditing
  ÷
  total # of runs performed)

Figure 8. Elements of Phase Two Results.

evidence for a procedure for a particular run indicates that a system element possesses acceptable reliability while the actual reliability of the element is unacceptable for the run, the sample results would be that underauditing has occurred.

In this manner the sample results for each procedure are tabulated over a number of simulation runs. Three measures of effectiveness are developed for each procedure. The probability of no sampling error is measured as the percentage of the total number of runs for which the sample results were correct. The probability of overauditing and the probability of underauditing are similarly calculated as the percentage of runs for which the sample results would lead to overauditing, or underauditing, respectively. Hence, phase two of the simulation allows the auditor, in effect, to gather many years (runs) of audit experience with the set of compliance procedures applied to the client's internal control system.

III. VALIDATION STEPS

Validation of the simulation tool was accomplished in three steps:

1. Random number tests.
2. Desk checking via trace code.
3. Mathematical and statistical testing of simulation results.

The random number tests were performed to test (1) the random number generator employed by the simulation and (2) the distributional processes (normal and uniform) derived from the generated random numbers. Desk checking was performed using trace code built into the simulation to verify transaction processing and procedure sampling activity. The final validation step involved the comparison of phase one results to analytical results for simple systems, and the comparison of phase two results to statistically expected results where feasible.

CHAPTER IV

RESULTS

This chapter discusses the results of the tests performed to validate the simulation tool and describes an application of the simulation tool to a typical payroll cycle.

I. VALIDATION STEPS

Validation of the simulation tool was accomplished in three steps:

1. Random number tests.
2. Desk checking via trace code.
3. Mathematical and statistical testing of simulation results.

This section describes the results of these tests and the implications for the conduct of simulation experiments.

Random Number Tests

In the initial validation step a number of statistical procedures were performed to test (1) the random number generator employed by the simulation and (2) the distributional processes (normal and uniform) derived from the generated random numbers. Statistical testing of the random number generator investigated the uniformity and independence properties of the generated random number sequence. Statistical testing of the derived distributional processes examined the goodness-of-fit of each derived (normal or uniform) distribution to the theoretical distribution.

The uniformity of the random number sequence produced by the random number generator was tested by applying the chi-square test and the Kolmogorov-Smirnov test. These tests addressed the goodness-of-fit of a sample of generated random numbers and the theoretical uniform distribution. Both tests utilized a null hypothesis of no detectable difference between the sample distribution and the theoretical distribution, and were applied to streams of 100, 500, and 1000 random numbers (Schmidt, 1970, p. 230). All tests were acceptable at the .05 significance level. The distribution of random numbers produced by the random number generator was concluded to possess acceptable uniformity.

The independence of the random number sequence produced by the random number generator was tested by applying runs tests, gap tests, and serial tests. These tests examined the arrangement of random numbers in a sequence of random numbers. Each test focused on a specific type of dependency which might be present in a random number sequence. For example, (1) the runs tests investigated the tendency of numbers to be followed by numbers above or below the mean (runs above or below the mean) or to be followed by a larger or smaller number (runs up and down), (2) the serial tests investigated the tendency of numbers to be followed by other numbers, and (3) the gap tests investigated the length of intervals between the recurrence of a given number. For each test a null hypothesis of random ordering (no detectable dependence) was utilized.

The tests of independence were applied to selected portions of the initial 1000 random numbers produced by the random number generator. All tests performed, except the serial tests, were acceptable at the .05

significance level. Because of the strength of the other independence test results, the failure of the serial tests was not judged to imply a serious departure from randomness. Furthermore, the design of the simulation compensates for dependencies which might be present by generating random numbers individually when needed rather than in tuples for each transaction (Fishman, 1973, p. 181). The distribution of random numbers produced by the random number generator was concluded to possess acceptable independence.

The goodness-of-fit of the derived distributional processes (normal and uniform) was tested by applying Kolmogorov-Smirnov tests. These tests measured the goodness-of-fit of a sample of distributed numbers (normal or uniform) and the theoretical (normal or uniform) distribution. A null hypothesis of no detectable difference between the sample distribution and the theoretical distribution (normal or uniform) was utilized. The tests were applied to samples of 100 numbers and were acceptable at the .05 significance level. The derived distributional processes were concluded to be acceptable.

Based on these tests, the random number generator and derived distributional processes were concluded to be acceptable for the purposes of this simulation.

Desk Checking Via Trace Code

The second validation step, desk checking via trace code, was performed to verify the transaction processing and sampling activity of the simulation. This verification was accomplished by activating a comprehensive system of trace code built into the simulation. This trace code allowed monitoring of all significant events in (1) the processing of individual transactions and (2) the sampling activity of individual compliance procedures.

For this purpose a test system (internal control system and compliance procedures) was developed which incorporated all major features of the simulation design. Using the trace code described above, the operation of phase one (transaction processing) and phase two (compliance procedure sampling) of the simulation was analyzed over a number of runs of the test system. Based on this examination, the simulation was observed to properly execute all phase one and phase two steps.

Testing of Simulation Results

The final validation step, testing of simulation results, was performed to verify the reasonableness of simulation results. The simulation tool was primarily designed for application to audit environments containing configurational or technological complexities. However, because the evaluation of internal controls and the appraisal of compliance procedures in complex systems can prove difficult, infeasible, or impossible via analytical or statistical means, the simple test system described earlier was used for the testing of simulation results. Although successful performance of the simple test system does not preclude the possibility of problems arising in more complex systems, strong evidence is provided.

Phase one simulation results were verified by comparing the average occurrence rates and reliabilities for various steps of the test system to analytically determined values. This verification produced three significant findings. First, for run sizes of 200 or greater the average simulated rates and reliabilities were extremely close (+2% or less) to expected values. Second, the variability of phase one results decreased rapidly as run size was increased. Generally, standard deviations for runs of 200 transactions ranged from 1% to 3%, while for runs of 1000 transactions standard deviations were typically less than 1%. Finally, in addition to indicating the satisfactory performance of phase one of the simulation, these results provided strong evidence of acceptable random number generation.

Phase two simulation results were verified by comparing the average results for various compliance procedures to expected results, over a number of replications of the test system. The determination of expected results hinged on an important property of the simulation--the realization that phase two involves two levels of sampling. In each phase two run (note that a replication of phase two embodies multiple runs), each procedure collects a sample of transactions from a population of transactions, which is itself a sample population from the set of all populations the internal control system might generate. Both sampling levels must be considered in the determination of phase two expected results. Because the true distribution of possible populations is not determinable, for purposes of verifying phase two of the simulation a normal distribution was assumed. In accordance with the central limit theorem, a normal distribution assumption was appropriate since the number of possible populations is very large.

Accordingly, the verification of phase two results involved three steps. First population mean and standard deviation values for pertinent final balance reliabilities (error or exception types) were estimated by utilizing phase one of the simulation. Second, these estimated population parameters and the sample critical values specified for each procedure were used to determine (approximate) the expected results for the respective procedures. The expected results were then compared to the simulation results for reasonableness. This approach was followed for phase two simulation experiments incorporating replications of 10 to 50 runs of 500 transactions each.

Three conclusions were drawn from this analysis of phase two results. First, phase two was stable and produced results for the various procedures which reasonably approximated expected results. Second, the closeness of simulation results and expected results improved as the number of replications (with each replication utilizing a different random number start position) and the number of runs per replication increased. Finally, the simulation results exhibited considerable variability, but this variability also decreased as the number of replications and the number of runs per replication increased.

Simulation Strategy

The validation process led to several conclusions regarding strategies for phase one and two of the simulation. For phase one, due to the rapid convergence and low variability of phase one results, satisfactory average results could be obtained via a small number (5 or 10) of runs of 500 to 1000 transactions. For phase two, a minimum of 10 replications of a minimum of 20 runs each was necessary to produce reasonably stable average results. Furthermore, because sample sizes of 100 transactions or more are often involved and because compliance procedures sample without replacement in the simulation; each run should include a minimum of 500 transactions. Run sizes of 500 transactions or larger are needed to reduce potential bias due to sampling from a finite population without replacement.

II. PAYROLL APPLICATION

To illustrate the steps involved in using the simulation tool and to demonstrate its usefulness, a typical application of the simulation to a payroll cycle will be presented. The payroll audit situation and preliminary review findings are first introduced to provide needed background.

Payroll Environment

The hypothetical audit application will involve the payroll cycle for a small manufacturing concern. Although the client has been a continuing engagement for several years, initial discussions were concerned with the many accounting system changes that have occurred since the completion of the previous audit. Foremost among these changes is the introduction of a computerized payroll accounting system. Partly as a result of this conversion, the client has recently experienced an unusually high turnover of key personnel in the payroll area.

The client's computerized payroll system is batch-oriented and utilizes keypunched cards for data entry. Payroll personnel data are stored in a payroll master file maintained on disk. Calculations for gross pay, deductions, net pay, updating of the master file, and printing of checks are all performed by the computer. The client views the batch system, which is unsophisticated by today's standards, as a significant first step towards a comprehensive management information system.

The auditor divided the payroll cycle into two overlapping subcycles: a payroll change subcycle and a paycheck processing subcycle. The payroll change subcycle initiates and updates payroll records for changes. The paycheck processing subcycle processes employee time cards and prints bi-weekly paychecks. In this illustration the audit simulation tool will be applied to the paycheck processing subcycle. A flowchart of the general processing activities comprising this subcycle is presented in Figure 9. In Figure 9, the general processing activities are denoted by numbered arrows.

Preliminary Review

As a guide in designing a tentative audit plan the auditor set up the following major internal control objectives for the subcycle:[2]

1. To determine that payroll payments are for work actually performed by authorized employees.
2. To determine that payroll transactions are properly authorized.

---

[2]This development is partly based on similar presentations in Arens and Loebbecke (1980) and Roberts (1978).

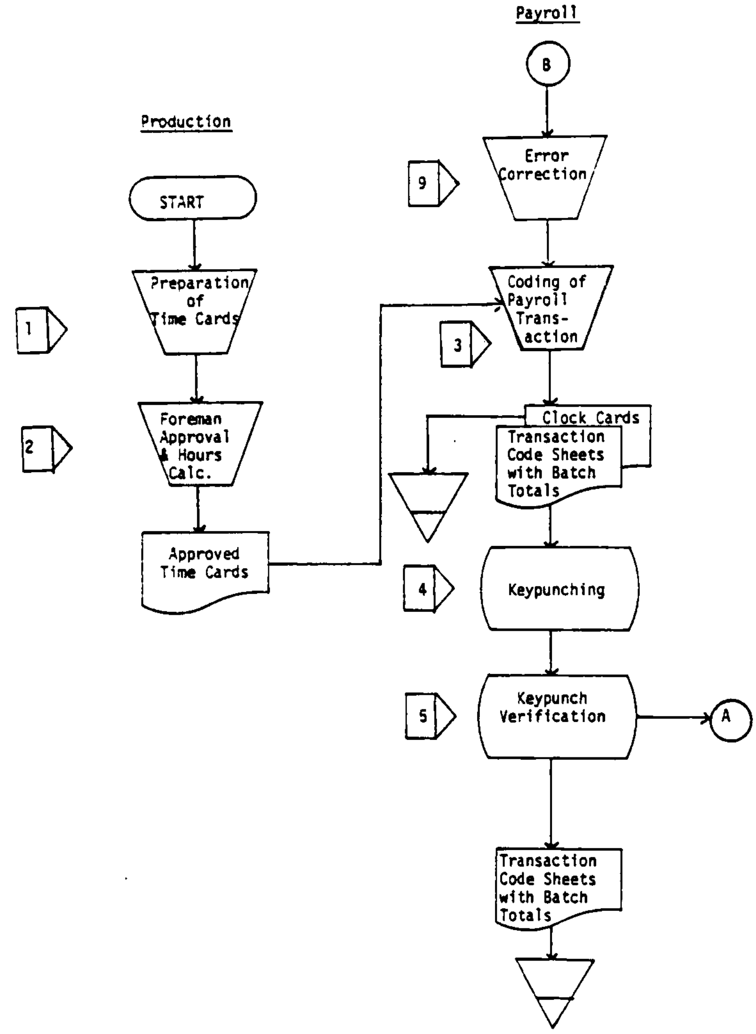


Figure 9. Payroll Subcycle Flowchart.

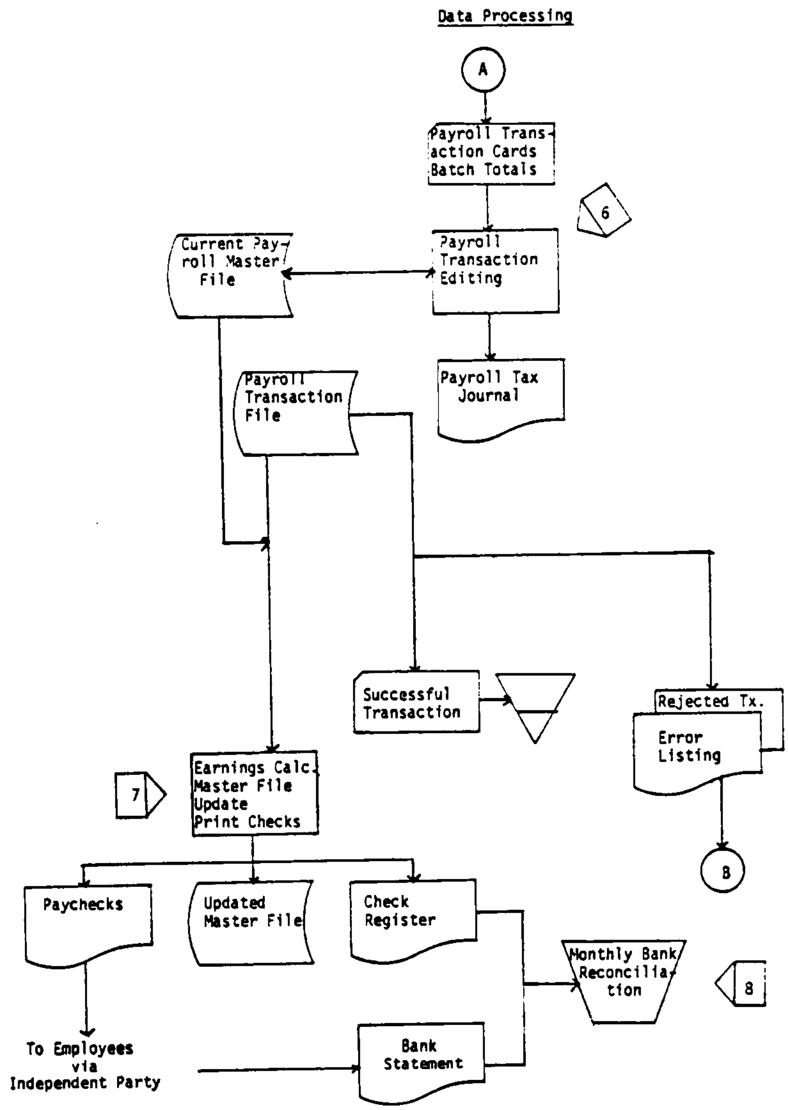


Figure 9 (Continued).

3. To determine that existing payroll transactions are properly recorded.

In light of these objectives, the auditor previously performed a preliminary review of internal control strengths and weaknesses in the subcycle. During this preliminary review major errors and irregularities that could occur in the subcycle and key controls that might prevent or detect these errors and irregularities were identified by the auditor.

The preliminary review findings regarding error and control relationships are summarized in Table 2. The auditor cited two major internal control weaknesses. First, it was noted that physical control over time cards prior to batching and keypunching is inadequate. Second, the auditor observed that the individual in charge of coding payroll transactions is also responsible for coding payroll change transactions (a functional component of the payroll change subsystem) and for making batch corrections. Although improprieties are not suspected, this triple role represents a serious weakness in segregation of duties. Furthermore, the auditor recognized three key system controls: foreman verification (C2 in Table 2), master file search for employee number (C4 in Table 2), and reasonableness tests for hours worked (C5 in Table 2). Since the latter two of these key controls are vested in the computer, the auditor feels that EDP auditing measures are mandated.

Overall, the auditor was satisfied with the internal control system. Tentative plans are to place reliance on certain key controls in order to reduce the extent of substantive testing. Of course, this planned reliance is contingent upon satisfactory compliance results.

TABLE 2

SUMMARY OF ERRORS AND CONTROLS

Activity No.	Error Code	Error Description	Identified Controls	Control Code	Control Description
1	E1	Time clocked for fictitious employee	C2,C4	C1	Use of time clock
	E2	Incorrect hours recorded	C1,C2,C5		
2	E3	Error in hours worked calculation	C5	C2	Foreman approval or verification
	E4	Fraudulent modification of time card	C4,C6		
	E5	Time card lost	None		
3	E6	Transaction coding error	C4,C5,C6		
	E7	Fraudulent modification of code sheet	None		
4	E8	Keypunch error	C3,C4,C5	C3	Keypunch verification
	E9	Duplicate or omitted transaction	C3,C6		
	E10	Transaction card lost	C6		
6	E11	Master file error	C7	C4	Master file search for employee number
				C5	Reasonableness tests for hours worked
				C6	Batch total check
7	E12	Calculation, update, or print error	C7,C8	C7	Reasonableness tests for gross pay, deductions, and net pay
				C8	Hash total check
9	E14	Batch correction error	C4,C5,C6		
	E15	Fraudulent batch modifications	C4,C5,C6		

Role of Simulation

The next step in the audit process involves the development of a tentative audit strategy for the subcycle. The simulation tool will be used to assist the auditor in making decisions regarding three specific aspects of this task.

First, the auditor has determined that compliance tests are necessary to assess the reliability of the foreman approval or verification process (C2 in Table 2). Compliance testing approaches contemplated include fixed sampling, sequential sampling, and dollar unit sampling. The simulation will be employed to assist the auditor in determining the relative efficiency and effectiveness of these alternative testing approaches, for varying sample sizes.

Second, the auditor has tentatively concluded that high reliance should be placed on the computer edit control for employee numbers (C4 in Table 2). Four EDP auditing approaches are under consideration: auditing around the computer, integrated test facility, test data, and parallel simulation. The auditor will utilize the simulation to evaluate the relative efficiency and effectiveness of these EDP approaches, for varying sample sizes.

Finally, given the segregation of duties shortcoming noted in the preliminary review, the auditor wishes to approximate the audit exposure that might result from collusion between the foreman and the individual responsible for transaction coding. The simulation will be used to investigate the reliability implications of this collusion possibility.

Use of the simulation tool for this application involved four major steps:

1. Formulation of internal control model specifications.
2. Phase one simulation experiments.
3. Formulation of input specifications for compliance procedures.
4. Phase two simulation experiments.

The phase one experiments were conducted (1) to determine the probable and maximum acceptable final balance reliabilities for the foreman approval process and the computer edit control for employee numbers, and (2) to investigate the audit exposure implications of collusion between the foreman and the transaction coder. Utilizing the phase one findings, the phase two experiments were performed to determine the relative efficiency and effectiveness of the various compliance testing procedures for the foreman approval process and the computer edit control for employee numbers.

Internal Control Model Specifications

The initial task to be accomplished in using the simulation tool is to develop input specifications for the internal control system. Based on the subsystem flowchart presented in Figure 9 and the preliminary review finding summarized in Table 2, the auditor configured a model of the system. The model consisted of the 14 processing steps, 7 control steps, and 4 branch steps delineated in Table 3. Note that many of the processing and control steps correspond directly with symbols on the system flowchart. For example, step number 1 (Invalid

TABLE 3

INTERNAL CONTROL MODEL STEPS

No.	Type[a]	Description
1	P	Invalid Employee
2	P	Hours Recorded Error
3	C	Foreman Verification
4	B	Branch for Correction of Time Error
5	P	Foreman Correction of Time Error
6	P	Transaction Coding Error - Employee Number
7	P	Transaction Coding Error - Hours or Rates
8	P	Transaction Coding Error - Batch Total
9	P	Keypunch Error - Employee Number
10	P	Keypunch Error - Hours or Rates
11	P	Keypunch Error - Batch Total
12	C	Keypunch Verification
13	B	Branch for Keypunch Correction
14	P	Keypunch Error Correction
15	P	Input Summary - Employee Number
16	C	Edit Check - Employee Number
17	C	Edit Check - Hours or Rates
18	C	Edit Check - Batch Total
19	B	Branch for Correction of Edit Error
20	P	Transaction Error Correction
21	P	Computer Calculation, Update, Print Error
22	C	Hash Total Check
23	P	Output Summary - Employee Number
24	C	Employee Review
25	B	Branch for Transaction Correction

[a]P = Processing Step, C = Control Step, B = Branch Step.

Employee) and step number 2 (Hours Recorded Error) from Table 3 represent the potential errors that might occur at the first processing activity (Preparation of Time Cards) in the Figure 9 system flowchart.

Input specifications were formulated which defined (1) the simulated transaction activity and (2) the internal control model steps, step attributes, and step interrelationships. Auditor judgment was involved in several aspects of this formulation process. First, the auditor was required to estimate the nature of the distribution of payroll transaction amounts and the distributional parameters. Second, for processing steps judgments were needed regarding (1) expected occurrence rates, (2) error amount distribution types and distributional parameters, and (3) maximum acceptable final balance error rates. Finally, for control steps the auditor had to estimate (1) exception rates and (2) maximum acceptable final balance exception rates.

These auditor judgments were made by consulting previous payroll cycle working papers and preliminary evidence already gathered for the current audit. For example, based on a simple analysis of payroll account activity for the current year the auditor approximated payroll transaction activity by a normal distribution with a mean of \$500, a standard deviation of \$50, a minimum value of \$300, and a maximum value of \$700. Error and exception occurrence rates were estimated from compliance testing results documented in payroll working papers for the previous year. Similarly, error amount distribution types and parameters were estimated based on compliance error analysis results for the previous year. Note that maximum acceptable final balance error and exception rates are used only in phase two of the simulation, and that phase one of the simulation is used to establish these maximum acceptable values. The appendix contains a computer listing, generated by the simulation, of all step specifications input by the auditor.

Phase One Simulation Experiments

Two sets of phase one simulation experiments were conducted. Each set involved an iterative strategy in which the auditor observed the sensitivity of final balance reliabilities for key processing and control steps over different error and exception rate settings. The first set of experiments assumed no collusion and sought to determine the probable and maximum acceptable final balance reliabilities for the foreman approval process (step 3) and the computer edit control for employee numbers (step 16). The second set of experiments included collusion between the foreman (step 3) and the transaction coder (step 6). All phase one simulation experiments employed 5 runs of 500 simulated transactions.

Phase one results without collusion. Figure 10 presents typical phase one simulation results without collusion for processing step 1 (Invalid Employee), control step 3 (Foreman Verification), and step 16 (Edit Check - Employee Number) for a typical simulation run. These results are interpreted as follows. For processing step 1, 20 errors (a 4% actual error rate) amounting to $10,259.05 occurred. All of the errors were detected by system controls (none were corrected via reprocessing) and none appeared in the final balance for the account, giving a system final balance reliability of 100% (appears as 99.99% due to

```
**********

 STEPNO=   1 NAME=  INV EMP
 TOT ACT= 500 ACT ERR RATE= 0.0400
 CRIT MAX FB OCC=    5
 ERRORS OCCURRED=  20 SYS DET=  20 ERRORS IN FB=    0
 CORR VIA REPROC=    0 DET VIA CONTROLS=  20
 TOT ERR AMT=    10259.05 FBERRAMT=          0.00
 SYS REL GIVEN ERR OCC= 1.0000 SYS FIN BAL REL= 0.9999

**********

 STEPNO=   3 NAME=  FMN VERIF
 NO OF EXC=  66 TOT ACT= 500 ACT EXC RATE= 0.1319
 EXCAMT=        922.09
 FIN BAL OCC=  45 FIN BAL REL= 0.9100
 CRIT MAX EXC=  60

 CONTROL DET  19 OF  20 OCC OF ERROR NO   1
 ERROR NAME=  INV EMP
 ERR AMT DET=      9704.16 PER CENT OF TOT ERR= 0.9459

 CONTROL DET  69 OF  82 OCC OF ERROR NO   2
 ERROR NAME=  HRS REC ERR
 ERR AMT DET=      1962.22 PER CENT OF TOT ERR= 0.8423

**********

 STEPNO=  16 NAME=  EDIT CHK - EMP NO
 NO OF EXC=  26 TOT ACT= 633 ACT EXC RATE= 0.0410
 EXCAMT=      6558.56
 FIN BAL OCC=  26 FIN BAL REL= 0.9479
 CRIT MAX EXC=  40

 CONTROL DET   1 OF  20 OCC OF ERROR NO   1
 ERROR NAME=  INV EMP
 ERR AMT DET=       554.89 PER CENT OF TOT ERR= 0.0540

 CONTROL DET  54 OF  52 OCC OF ERROR NO   6
 ERROR NAME=  TX CODING ERR - EMP NO
 ERR AMT DET=     27657.26 PER CENT OF TOT ERR= 1.0384

 CONTROL DET  21 OF  97 OCC OF ERROR NO   9
 ERROR NAME=  KEYPUNCH ERR - EMP NO
 ERR AMT DET=     10459.07 PER CENT OF TOT ERR= 0.2176
```

Figure 10. Typical Phase One Results for Payroll Subcycle.

computer division) and a system reliability given the error occurred also of 100% (all errors were corrected by the system).

For control step 3, 66 exceptions (a 13.19% actual exception rate) amounting to a total exception amount of $922.09 occurred. Of the 66 exceptions, 45 appeared in the final balance for the account giving a final balance reliability of 91%. The control detected 19 of 20 occurrences of step 1 (Invalid Employee); for an error detection amount of $9704.16 or 94.59% of the total step 1 error amount. The control also detected 69 of 82 occurrences of step 2 (Hours Recorded Error) for an error detection amount of $1962.22 or 84.23% of the total step 2 error amount. The results for step 16 (Edit Check - Employee Number) are interpreted in this same manner. Note that control steps 3 and 16 together detected all of the 20 step 1 errors that occurred.

Table 4 summarizes the average phase one simulation results (without collusion) for these system elements over 5 simulation runs. The analysis in Table 4 indicates that although step 1 (Invalid Employee) errors occurred at an actual rate of 4.08%, the system effectively detected and corrected these errors giving a 100% final balance reliability for step 1 errors. Furthermore, exceptions for control step 3 occurred at an actual rate of 13.16% yielding a final balance reliability of 91.67% (i.e. approximately 8-9% of the completed transactions had this deviation associated with it). The results for step 16 (Edit Check - Employee Number) are interpreted in the same manner.

Based on these final results and sensitivity observations made over a number of preliminary simulation runs, the auditor determined that the expected final balance exception rate for step 3 (Foreman

TABLE 4

PHASE ONE SIMULATION RESULTS WITHOUT COLLUSION

Step No.	Description	Specified Occ. Rate	Actual Occ. Rate (S.D.)	Fin. Bal. Reliability (S.D.)
1	Invalid Employee	5%	4.08% (.18%)	100% (0%)
3	Foreman Verification	15%	13.16% (.17%)	91.67% (1.68%)
16	Edit Check-Employee No.	5%	4.29% (.17%)	94.55% (.22%)

Verification) was approximately 9% and that the maximum acceptable final balance exception rate would be established as 12%. In addition, for step 16 (Edit Control - Employee Number) the auditor determined that a 5% final balance exception rate was expected and that a maximum acceptable final balance rate of 7% was appropriate. These findings were used directly in phase two of the simulation.

Phase one results with collusion. The second set of phase one simulation experiments included collusion between the foreman (step 3) and transaction coder (step 6). This collusive activity involved the initiation and approval of a time card for a fictitious employee by the foreman, for which the transaction coder had caused a fraudulent master file employee number to be entered.

Modeling this collusive activity required five input specification changes. First, step 1 (Invalid Employee) was changed to include an irregularity occurrence pattern of 50. This change caused step 1 errors to occur every 50th transaction as well as randomly at the originally specified rate (5%). Second, step 3 (Foreman Verification) was changed to include collusion with step 1 (Invalid Employee) at a rate of 30%. Thus, step 3 exceptions would occur 30% of the time the current transaction has a step 1 error, as well as randomly at the originally specified rate (15%). A collusion rate of 30% was selected to represent a rate high enough to generate a material embezzlement amount yet low enough to avoid direct implication of the conspirators, should the fraud be discovered. Third, step 16 (Edit Control - Employee Number) was similarly changed to include collusion with step 1 (Invalid Employee) at the same rate. Fourth, since the transaction coder also performs batch corrections, step 20 (Transaction Correction) was changed so that step 1 errors would not be corrected. Finally, since a fictitious employee is involved, step 24 (Employee Review) was changed so that step 1 errors (Invalid Employee) would not be detected.

With these system modifications, a second set of phase one simulation experiments were performed. The simulation results indicated that the presence of collusion reduced the probable final balance reliability of step 1 (Invalid Employee) from 100% to approximately 97%. The latter amounted to an increased exposure of approximately $8500. Because this exposure was considered material and no compensating controls were identified, the auditor concluded that if foreman verification was to be relied upon the tentative audit plan must be modified to include stringent compliance testing of this key control.

Phase II Simulation Experiments

The auditor utilized phase two of the simulation to determine (1) the relative efficiency and effectiveness of fixed, sequential, and dollar unit sampling plans for compliance testing of step 3 (Foreman Verification) and (2) the relative efficiency and effectiveness of auditing around the computer, parallel simulation, integrated test facility, and test data approaches for compliance testing of step 16 (Edit Check - Employee Number). Phase two of the simulation involved an iterative strategy in which the auditor observed the efficiency and effectiveness characteristics of various compliance testing procedures for varying sample size and critical (sample acceptance) value combinations. For each procedure, the efficiency is measured by the sample size and effectiveness is measured by the simulated probability of no sampling error, the probability of underauditing, and the probability of overauditing. This section describes the input specifications for compliance procedures developed by the auditor and discusses the results of the first iteration of phase two experiments.

Input specifications for compliance procedures. The first task to be accomplished in using phase two of the simulation was to formulate input specifications for the compliance procedures to be evaluated. Because it was desired to investigate sample sizes of 25, 50, and 100 for each of the seven procedure types (three for step 3, four for step 16), the auditor developed input specifications defining a total of 21 compliance procedures. Furthermore, to provide additional sensitivity information the auditor included a range of critical (sample acceptance) values to be evaluated for each procedure (except parallel simulation and sequential sampling).

Table 5 summarizes the 21 compliance procedure specifications developed initially by the auditor. The 21 procedures included three sample size levels for each of seven procedure types. The first nine procedures defined (three each of fixed sampling, dollar unit sampling, and sequential sampling) sample control step 3 (Foreman Verification). A range of critical (sample acceptance) values were specified for each fixed sampling and dollar unit sampling procedure. For example, each sample of 25 transactions collected by fixed sampling procedure 1 is successively evaluated against critical values of 2, 3, 4, and 5 sample occurrences. Thus, procedure 1 might be alternatively viewed as 4

TABLE 5

SUMMARY OF COMPLIANCE PROCEDURE SPECIFICATIONS

No.	Type[a]	Sample Size	Step Sampled	Critical Values and Other
1	F	25	3	2,3,4,5
2	F	50	3	4,5,6,7
3	F	100	3	5,6,8,9
4	D	25	3	2,3,4,5
5	D	50	3	4,5,6,7
6	D	100	3	5,6,8,9
7	S	15,35	3	3/15, 5/35
8	S	30,60	3	4/30, 8/60
9	S	60,120	3	7/60, 13/120
10.	A	25	15,23	1,3, Criteria Type=3
11	A	50	15,23	2,5, Criteria Type=3
12	A	100	15,23	4,8, Criteria Type=3
13	P	25	16	Mat=$200
14	P	50	16	Mat=$400
15	P	100	16	Mat=$800
16	I	25[b]	16	2,3,4
17	I	50[b]	16	3,4,5
18	I	100[b]	16	4,5,6
19	T	25[c]	16	2,3,4
20	T	50[c]	16	4,5,6
21	T	100[c]	16	8,10,12

[a]F = Fixed Sampling, D = Dollar Unit Sampling, S = Sequential Sampling, A = Around the Computer, P = Parallel Simulation, I = Integrated Test Facility, T = Test Data.

[b]ITC pattern was random.

[c]No errors were initialized.

separate fixed sampling procedures each using a sample size of 25. The sequential sampling procedures involve a twofold sampling plan. For example, sequential procedure 7 first evaluated an initial sample of 15 transactions against a critical value of 3 errors. If the initial sample contained 3 or more errors a larger second sample of 35 transactions was evaluated against a critical value of 5 errors, otherwise the first sample was accepted. The critical values for each procedure were established by using statistical tables with a confidence level of 90% as a guideline. The sample size combinations for sequential procedures were subjectively determined to potentially provide a lower average sample size than fixed or dollar unit sampling alternatives (i.e., an initial sequential sample of 15 followed by a second sample of 35 could yield a lower average sample size than a fixed sample of 25).

The remaining procedures in Table 5 (procedures 10-21) are EDP auditing procedures for verifying computer control step 16 (Edit Check - Employee Number). Auditing around the computer procedures 10-12 did not directly sample step 16, the computer control under examination. This is because, by definition, around the computer techniques test computer controls indirectly by comparing computer input to computer output. Consequently, an input summary step (step 15) and an output summary step (step 23) were included in the model specifically for this purpose. The input summary step registers an error only if an error affecting the employee number is present in the computer input for a transaction, while the output summary step registers an error only if an error affecting the employee number is present in the computer output.

Appropriately, the auditing around the computer procedures sample these summary steps. Criteria type 3 indicates that an error was considered detected whenever, for a sampled transaction, an input error (step 15) was not corrected by computer processing and appeared in the computer output (step 23).

Based on phase one simulation findings, the auditor revised the maximum acceptable final balance occurrence rate for step 3 (Foreman Verification) to 12%. The maximum acceptable final balance occurrence rate for step 16 (Edit Check - Employee Number) was similarly adjusted to 7% to reflect the phase one findings. In addition, the auditor set the maximum acceptable final balance occurrence rate for input summary step 15 and output summary step 23 (both are sampled by the auditing around the computer procedures) to 1%. This unusually low rate was initially selected to compensate for the fact that computer control step 3 was not directly examined by these procedures.

Phase two simulation results. The auditor established an initial strategy entailing 10 replications of 20 runs each with each run consisting of 500 transactions. Additional simulation experiments would then be performed, if needed, with appropriate modifications. The auditor also determined that only procedures offering an expected probability of underauditing of 10% or less and a probability of overauditing of 20% or less would be considered for the audit.

The auditor executed this initial strategy and obtained the initial simulation results exhibited in Table 6. Table 6 lists, for each of the 21 defined procedures, only the critical value that provided

TABLE 6

INITIAL PHASE TWO SIMULATION RESULTS

Procedure Type	Sample Size	Step Sampled	Critical Value	Probability Over $\overline{X}$ (S.D.)	Probability Under $\overline{X}$ (S.D.)
1. Fixed[a]	25	3	4	.14 (.03)	.10 (.05)
2. Fixed[a]	50	3	7	.05 (.04)	.10 (.04)
3. Fixed	100	3	9	.53 (.11)	.02 (.03)
4. DUS[a]	25	3	4	.18 (.09)	.09 (.06)
5. DUS	50	3	7	.21 (.09)	.09 (.03)
6. DUS	100	3	9	.53 (.08)	.02 (.03)
7. SEQ	AVG=21	3	3/15,5/35	.02 (.03)	.12 (.03)
8. SEQ	AVG=47	3	3/30,8/60	.05 (.05)	.11 (.04)
9. SEQ[a]	AVG=104	3	7/60,13/120	.12 (.06)	.09 (.05)
10. ARND	25	15,23	1	.05 (.03)	.27 (.07)
11. ARND	50	15,23	2	.00 (.00)	.31 (.05)
12. ARND	100	15,23	4	.00 (.00)	.32 (.04)
13. ITF	25	16	3	.15 (.05)	.15 (.05)

TABLE 6 (Continued)

Procedure Type	Sample Size	Step Sampled	Critical Value	Probability Over $\overline{X}$ (S.D.)	Probability Under $\overline{X}$ (S.D.)
14. ITF	50	16	4	.23 (.10)	.11 (.07)
15. ITF	100	16	8	.16 (.08)	.11 (.05)
16. TEST DATA	25	16	2	.36 (.17)	.13 (.04)
17. TEST DATA	50	16	4	.39 (.08)	.16 (.04)
18. TEST DATA	100	16	8	.33 (.04)	.17 (.05)
19. PAR SIM	25	16	MAT=$200	.05 (.04)	.14 (.06)
20. PAR SIM	50	16	MAT=$400	.06 (.04)	.24 (.04)
21. PAR SIM	100	16	MAT=$800	.00 (.00)	.24 (.04)

[a]Meets auditor's risk criteria.

risk levels that met or best approximated the auditor's established risk criteria. Note that only one critical value is allowed for each sequential procedure and only one materiality level is allowed for each parallel simulation procedure. Table 6 excludes the probability of no sampling error because the auditor's risk criteria are expressed in terms of the probability of underauditing and the probability of overauditing only. The simulation results appearing in Table 6 reveal that four traditional sampling procedures (denoted by an a in Table 6) for verifying control step 3 (Foreman Verification) met the auditor's risk criteria, while none of the EDP auditing procedures for verifying computer control step 16 (Edit Check - Employee Number) met these criteria.

Table 6 simulation results for traditional sampling procedures 1 through 9 (fixed, dollar unit, and sequential sampling procedures) indicate that fixed sampling procedures 1 and 2, dollar unit sampling procedure 4, and sequential sampling procedure 9 met the auditor's criteria. Furthermore, fixed sampling procedure 3 and dollar unit sampling procedures 5 and 6 exceeded the auditor's risk criterion for overauditing because the respective critical (sample acceptance) values were too low (conservative). This suggests that larger critical values should be included for these procedures if additional phase two simulation experiments are deemed necessary.

In addition, Table 6 indicates that sequential procedures 7, 8, and 9 may provide a cost advantage over alternative fixed or dollar unit procedures with comparable sample sizes. For example, sequential procedure 7 offers comparable risk levels as the fixed or dollar unit sampling alternatives (with sample sizes of 25) with a smaller average sample size of 21. Similarly, with a comparable probability of underauditing, sequential procedure 8 provides a lower probability of overauditing and a smaller average sample size (of 47) than the fixed or dollar unit sampling alternatives (with sample sizes of 50). Finally, while sequential procedure 9 requires a slightly larger average sample size (of 104), the procedure offers much lower risk levels than fixed or dollar unit sampling alternatives (with sample sizes of 100). Due to the closeness of the results for these sequential procedures to the auditor's established criteria, subsequent phase two iterations, if needed, should further explore these procedures without modification.

Since the initial phase two simulation results presented in Table 6 indicate that none of the EDP auditing procedures (auditing around the computer, ITF, test data, and parallel simulation procedures) for verifying computer control step 16 (Edit Check - Employee Number) met the auditor's risk criteria, further investigation of these procedures may be warranted. If deemed necessary, this further investigation might encompass a second iteration of phase two simulation experiments with modifications to the specifications for these EDP auditing procedures, as discussed below.

Table 6 results for ITF procedures 13, 14, and 15 closely approximated the auditor's established risk criteria. For example, ITF procedure 15 was rejected because its probability of underauditing of 11% exceeded the established criterion by 1%. Also, ITF procedure 14 exceeded the established criterion for underauditing by only 1% and exceeded the criterion for overauditing by only 3%. Hence, if subsequent phase two experiments are performed the characteristics of these procedures, without modification, should be further explored.

Table 6 indicates that none of the three test data procedures 16, 17, or 18 satisfied either of the auditor's established risk criteria. Since for each procedure both the probability of underauditing and the probability of overauditing were excessive, these procedures should be excluded from further consideration by the auditor. However, because none of these test data procedures utilized a test data set including transactions with initialized errors, any additional phase two experiments might substitute test data procedures incorporating this test data option for the original test data procedures.

The results for parallel simulation procedures 19, 20, and 21 appearing in Table 6 reveal an excessive probability of underauditing and an extremely low probability of overauditing for each procedure. This implies that the initial materiality level for each procedure was set too high. Hence, any further phase two experiments that might be performed should include a lower materiality level for each parallel simulation procedure.

Finally, the Table 6 results for auditing around the computer procedures 10, 11, and 12 provide inconclusive evidence regarding the operation of computer control step 16. Because the probabilities of underauditing for these procedures is non-zero the results for these procedures provide evidence only that in excess of 1% (the maximum acceptable final balance error rate established for input and output summary steps 15 and 23) of the final balance transactions have an associated error affecting the employee number. However, since computer step 16 was not directly examined by these procedures, no specific conclusions regarding the operation of computer step 16 can be made. Nevertheless, the auditor may wish to assume that these final balance employee number errors imply control exceptions for computer control step 16. If so, the auditor may desire to further explore these procedures in a subsequent iteration of simulations, with the maximum acceptable final balance error rate of input and output summary steps 15 and 23 increased to 7% (the maximum acceptable final balance exception rate established for step 16).

At this point the auditor could modify the compliance procedure specifications to reflect the above findings, and proceed with a second iteration of phase two simulations. This iterative process could be continued until an acceptable set of procedures was identified by the auditor.

Summary. Use of the simulation tool in a typical computerized payroll audit situation was described. Phase one of the simulation was employed to assist the auditor in evaluating the reliability of the internal control system with respect to the expected and maximum acceptable final balance exception rates for two specific control steps in the payroll cycle. These expected and maximum acceptable rates were subsequently used in phase two of the simulation. In addition, phase one of the simulation was used to investigate the potential audit exposure resulting from a specific collusion possibility observed in the payroll cycle. Phase two of the simulation was employed to assist the auditor in appraising the efficiency and effectiveness of three traditional sampling approaches for verifying a manual control, and of four EDP auditing approaches for verifying a computer control. The phase two simulation results provided a basis for significantly narrowing the set of potential compliance procedures for the payroll cycle.

CHAPTER V

CONCLUSION

A computer simulation tool was developed to assist the auditor in the planning of compliance testing procedures for transaction cycles or subcycles. The simulation tool was designed to facilitate three specific aspects of this task:

1. Evaluating the overall reliability of the cycle with respect to specific errors.
2. Establishing acceptable compliance levels for individual controls in the cycle.
3. Appraising the relative efficiency and effectiveness of alternative compliance testing procedures contemplated for the cycle.

I. SUMMARY

Based on auditor specifications for a particular transaction cycle, the simulation constructs a computer model of the cycle's internal control system and of alternative compliance testing procedures contemplated for the cycle. The simulation consists of two operational phases. Phase one of the simulation monitors the processing of a number of transactions by the internal control system and develops reliability statistics for the various elements of the system. This reliability data is output by the simulation as phase one simulation results.

Phase two of the simulation expands this simulated transaction processing by invoking the compliance procedures. Three traditional sampling approaches (fixed sampling, dollar unit sampling, and sequential sampling) and four EDP approaches (auditing around the computer, parallel simulation, integrated test facility, and test data) may be evaluated. Phase two of the simulation monitors the transaction sampling activity of each procedure and develops three measures of effectiveness for each procedure: the probability of no sampling error, the probability of overauditing, and the probability of underauditing. These effectiveness measures for each procedure are output by the simulation as phase two simulation results.

The usefulness of the simulation tool was demonstrated by application to a typical, computer-based payroll cycle. The simulation results can assist the auditor by providing a basis for screening the set of potential compliance procedures for the cycle.

II. CONTRIBUTIONS

This research proposes a simulation tool to assist an auditor in the evaluation of internal control. Three significant contributions are made to the literature in this area.

First, the study is the first to offer a framework for appraising the relative efficiency and effectiveness of alternative compliance testing procedures for specific audit situations. The simulation tool provides a risk-free environment in which an auditor can investigate the probable outcome of alternative compliance strategies, before audit resources are committed.

Second, the study marks the first effort to assess the impact of collusion on internal control reliability and audit exposure. This constitutes an extension of previous research by Yu and Neter (1973), Cushing (1974), and Burns and Loebbecke (1975), which assumed independent stochastic internal control system elements.

Finally, the study provides the first simulation tool generalizable to different audit applications. The simulation tool can be tailored to particular audit situations without knowledge of computer programming languages. This embodies a needed refinement to previous simulation approaches which were programmed for single applications and required programming expertise to employ.

III. LIMITATIONS

The simulation tool developed in this research is limited in several respects. This section addresses five major limitations of the study.

First, like all others, this simulation effort involves an abstraction from the real world. As such, the simulation is not capable of including all real world factors affecting the internal control environment. For example, a myriad of human elements that clearly affect internal control reliability are not captured by the simulation.

Second, the simulation has certain scope limitations. For example, the simulation implements only four EDP audit approaches. Furthermore, because EDP audit techniques are not standardized, the

EDP techniques included are based upon general descriptions appearing in the literature and certainly differ from many real world applications. Similarly, the simulation incorporates but one irregularity pattern (cyclic), which will not comprehend all possible schemes, and only two distribution types (normal and uniform).

Third, the usefulness of the simulation was demonstrated for a single payroll application. A payroll application was selected in part because payroll cycles typically have few interactions with other audit cycles. Hence, although the simulation should be applicable to other payroll cycles, its general application to other audit cycles is not assured.

Fourth, even though the simulation requires no programming expertise, formulation of input specifications for the simulation requires a degree of modeling expertise. However, the level of modeling expertise needed is minimal, and comparable to that needed for flowchart preparation.

Fifth, computer execution time for phase two of the simulation was considerable. The payroll application described in Chapter IV was performed on a DEC-10 computer in a timesharing environment. A phase two experiment for this application, involving 20 runs of 500 transactions each, required approximately 2 minutes of execution time. However, execution times would differ for other machines. Ideally, the simulation would be used in a dedicated computer environment in which, although execution times may be larger, competition with other users for computer resources is not involved.

IV. RESEARCH IMPLICATIONS

This research demonstrates that a simulation approach can provide valuable assistance to auditors in the evaluation of internal control. Additional research is needed to extend the present study and to investigate the usefulness of simulation in other audit areas.

The scope limitations of the simulation previously cited signal the need for a number of refinements. The simulation design could be extended to accommodate additional EDP audit approaches, irregularity patterns, and distribution types. Another needed refinement would be the inclusion of multiple transaction types. For example, for the payroll application described in Chapter IV a second transaction type might have been defined to trigger a bank statement reconciliation, or perhaps a computer processing activity which occurs periodically and not for every transaction. This added feature would allow internally generated transactions to be modeled and would provide improved flexibility for modeling computerized processing activity.

The simulation tool developed in the present study produces reliability data that would be useful to systems analysts for the design of manual or computerized control systems. Additional research is needed to explore the usefulness of simulation for the design of internal control systems.

The present study focused on the usefulness of a simulation approach for appraising compliance testing procedures. Other research efforts might develop simulation approaches for evaluating substantive testing procedures or analytical review procedures.

Finally, input specifications for the simulation tool developed in this study require the auditor to make judgments regarding error occurrence patterns and error amount distributions. At this time, however, very little is known about the nature of accounting populations. Additional research is needed to investigate the error characteristics of real world accounting populations.

LIST OF REFERENCES

LIST OF REFERENCES

American Institute of Certified Public Accountants, The Commission on Auditors' Responsibilities: Report, Conclusions, and Recommendations (AICPA, 1978).

________, Computer-Assisted Audit Techniques (AICPA, 1979).

________, Statements on Auditing Standards (AICPA, 1981).

Anderson, R. J., and A. D. Teitlebaum, "Dollar-unit Sampling," Canadian Chartered Accountant (April 1973), pp. 30-39.

Arens, A. A., and J. K. Loebbecke, Auditing: An Integrated Approach (Prentice Hall, Inc., 1980).

Arkin, H., "Statistical Sampling and Internal Control," The CPA Journal (January 1976), pp. 15-18.

Bodnar, G., "Reliability Modeling of Internal Control Systems," The Accounting Review (October 1975), pp. 747-757.

Burch, J. G., and J. L. Sardinas, Computer Control and Audit: A Total Systems Approach (John Wiley & Sons, Inc., 1978).

Burns, D. C., and J. K. Loebbecke, "Internal Control Evaluation: How the Computer Can Help," Journal of Accountancy (August 1975), pp. 60-70.

Carmichael, D. R., "Behavioral Hypotheses of Internal Control," The Accounting Review (April 1970), pp. 235-245.

Cash, J. I., A. D. Bailey, and A. B. Whinston, "A Survey of Techniques for Auditing EDP-Based Accounting Information Systems," The Accounting Review (October 1977), pp. 813-832.

________, "The TICOM Model--A Network Data Base Approach to Review and Evaluation of Internal Control Systems," Proceedings of the American Federation of Information Processing Societies Conference (AFIPS, 1977), pp. 843-854.

Cushing, B. E., "A Mathematical Approach to the Analysis and Design of Internal Control Systems," The Accounting Review (January 1974), pp. 24-41.

Elliott, R. K., and J. R. Rogers, "Relating Statistical Sampling to Audit Objectives," Journal of Accountancy (July 1972), pp. 46-55.

Fishman, G. S., Concepts and Methods in Discrete Event Digital Simulation (John Wiley & Sons, Inc., 1973).

Goodfellow, J. L., J. K. Loebbecke, and J. Neter, "Some Perspectives on CAV Sampling," Part I, Canadian Chartered Accountant (October 1974), pp. 23-30; Part II, Canadian Chartered Accountant (November 1974), pp. 46-53.

Hamlen, S., "A Chance-Constrained Mixed Integer Programming Model for Internal Control Design," The Accounting Review (October 1980), pp. 578-593.

Kinney, W. R., "A Decision Theory Approach to the Sampling Problem in Auditing," Journal of Accounting Research (Spring 1975), pp. 117-132.

Loebbecke, J. K., and J. Neter, "Considerations in Choosing Statistical Sampling Procedures in Auditing," supplement to the Journal of Accounting Research (1975), pp. 38-52.

Mair, W. C., D. R. Wood, and K. W. Davis, Computer Control and Audit, 2d ed. (IIA, Inc., 1976).

Maxim, L. D., D. E. Cullen, and F. X. Cook, "Optimal Acceptance Sampling Plans for Auditing 'Batched' Stop and Go vs. Conventional Single-Stage Attributes Plans," The Accounting Review (January 1976), pp. 97-109.

Neter, J., and J. K. Loebbecke, "Behavior of Major Statistical Estimators in Sampling Accounting Populations: An Empirical Study," Auditing Research Monograph No. 2 (AICPA, 1975).

Ramage, J. G., A. M. Krieger, and L. L. Spero, "An Empirical Study of Error Characteristics in Audit Populations," supplement to the Journal of Accounting Research (1979), pp. 72-102.

Reneau, J. H., "CAV Bounds in Dollar Unit Sampling: Some Simulation Results," The Accounting Review (July 1978), pp. 669-680.

Roberts, D., Statistical Auditing (AICPA, 1978).

Schmidt, J. W., Simulation and Analysis of Industrial Systems (Richard D. Irwin, Inc., 1970).

Smith, K., "Internal Control and Audit Sample Size," The Accounting Review (April 1972), pp. 260-269.

Stanford Research Institute, Systems Auditability and Control Study: Data Processing Audit Practices Report (IIA, Inc., 1977).

Warren, C. S., "Audit Risk," Journal of Accountancy (August 1979), pp. 66-74.

Weber, R., "Auditor Decision Making on Overall System Reliability: Accuracy, Consensus, and the Usefulness of a Simulation Decision Aid," Journal of Accounting Research (Autumn 1978), pp. 368-388.

Weber, R., EDP Auditing: Conceptual Foundations and Practice (McGraw-Hill, Inc., 1982).

Yu, S., and J. Neter, "A Stochastic Model of the Internal Control System," Journal of Accounting Research (Autumn 1973), pp. 273-295.

APPENDIX

APPENDIX A-1

```
***THE IC SYSTEM HAS THE FOLLOWING PROCESS STEPS***


************************************************************

STEPID=    1 STEPTYPE= P STEPNAME=  INV EMP

NXTSTEP=    2 ERRATE= 0.0500 LINK=    2 IRRFLAG= N
CRIT MAX FIN BAL OCC= 0.0100
DTYPE= N MEAN= 500.00 STDEV=  50.00 MIN= 300.00 MAX= 700.00

************************************************************

STEPID=    2 STEPTYPE= P STEPNAME=  HRS REC ERR

NXTSTEP=    3 ERRATE= 0.1500 LINK=    5 IRRFLAG= N
CRIT MAX FIN BAL OCC= 0.0500
DTYPE= N MEAN=  30.00 STDEV=  10.00 MIN=    5.00 MAX= 100.00

************************************************************

STEPID=    5 STEPTYPE= P STEPNAME=  FMN CORR OF TIME CARD ERR

NXTSTEP=    6 ERRATE= 0.1000 LINK=    6 IRRFLAG= N
CRIT MAX FIN BAL OCC= 0.1000
NON-MONETARY
STEPS REPROCESSED ARE :       1      2      3

************************************************************

STEPID=    6 STEPTYPE= P STEPNAME=  TX CODING ERR - EMP NO

NXTSTEP=    7 ERRATE= 0.1000 LINK=    7 IRRFLAG= N
CRIT MAX FIN BAL OCC= 0.0500
DTYPE= N MEAN= 500.00 STDEV=  50.00 MIN= 300.00 MAX= 700.00
```

Figure A-1. Processing Step Specifications.

```
*****************************************************

STEPID=   7 STEPTYPE= P STEPNAME=  TX CODING ERR - HRS OR RATES

NXTSTEP=   8 ERRATE= 0.1000 LINK=   8 IRRFLAG= N
CRIT MAX FIN BAL OCC= 0.0500
DTYPE= N MEAN=  50.00 STDEV=  10.00 MIN=   5.00 MAX= 125.00

*****************************************************

STEPID=   8 STEPTYPE= P STEPNAME=  TX CODING ERR - BATCH TOT

NXTSTEP=   9 ERRATE= 0.0100 LINK=   9 IRRFLAG= N
CRIT MAX FIN BAL OCC= 0.0500
NON-MONETARY

*****************************************************

STEPID=   9 STEPTYPE= P STEPNAME=  KEYPUNCH ERR - EMP NO

NXTSTEP=  10 ERRATE= 0.1500 LINK=  10 IRRFLAG= N
CRIT MAX FIN BAL OCC= 0.0500
DTYPE= N MEAN= 500.00 STDEV=  50.00 MIN= 300.00 MAX= 700.00

*****************************************************

STEPID=  10 STEPTYPE= P STEPNAME=  KEYPUNCH ERR - HRS OR RATES

NXTSTEP=  11 ERRATE= 0.1500 LINK=  11 IRRFLAG= N
CRIT MAX FIN BAL OCC= 0.0500
DTYPE= N MEAN=  50.00 STDEV=  10.00 MIN=   5.00 MAX= 125.00

*****************************************************

STEPID=  11 STEPTYPE= P STEPNAME=  KEYPUNCH ERR - BATCH TOT

NXTSTEP=  12 ERRATE= 0.0100 LINK=  14 IRRFLAG= N
CRIT MAX FIN BAL OCC= 0.0500
NON-MONETARY
```

Figure A-1 (Continued).

```
*********************************************************

STEPID=  14 STEPTYPE= P STEPNAME=  KEYPUNCH ERR CORR

NXTSTEP=  15 ERRATE= 0.1000 LINK=  15 IRRFLAG= N
CRIT MAX FIN BAL OCC= 0.1500
NON-MONETARY
STEPS REPROCESSED ARE :       9     10     11     12

*********************************************************

STEPID=  15 STEPTYPE= P STEPNAME=  INP SUMMARY - EMP NO

NXTSTEP=  16 ERRATE= 0.0000 LINK=  20 IRRFLAG= N
CRIT MAX FIN BAL OCC= 0.0500
NON-MONETARY
DEP STEPS ARE:       1     6     9

*********************************************************

STEPID=  20 STEPTYPE= P STEPNAME=  TX CORR ERR

NXTSTEP=   9 ERRATE= 0.1000 LINK=  21 IRRFLAG= N
CRIT MAX FIN BAL OCC= 0.1500
NON-MONETARY
STEPS REPROCESSED ARE :       1     2     3     5     6     7     8

*********************************************************

STEPID=  21 STEPTYPE= P STEPNAME=  CALC, UPDATE, PRINT ERR

NXTSTEP=  22 ERRATE= 0.0100 LINK=  23 IRRFLAG= N
CRIT MAX FIN BAL OCC= 0.0050
DTYPE= N MEAN= 100.00 STDEV=  25.00 MIN=  10.00 MAX= 200.00

*********************************************************

STEPID=  23 STEPTYPE= P STEPNAME=  OUT SUMMARY - EMP NO

NXTSTEP=  24 ERRATE= 0.0000 LINK=   0 IRRFLAG= N
CRIT MAX FIN BAL OCC= 0.0500
NON-MONETARY
DEP STEPS ARE:       1     6     9    21

***END OF PROCESS LIST***
```

Figure A-1 (Continued).

APPENDIX A-2

```
***THE IC SYSTEM HAS THE FOLLOWING CONTROL STEPS***



**********************************************************


STEPID=    3 STEPTYPE= C STEPNAME=  FMN VERIF

ERRORS CONTROLLED ARE:       1      2
NEXTSTEP=    4 BRFLGSTP=    4
LINK=   12 EXCRATE= 0.1500 COLUFLG= N
CRIT MAX FIN BAL OCC= 0.1200

**********************************************************


STEPID=   12 STEPTYPE= C STEPNAME=  KEYPUNCH VERIF

ERRORS CONTROLLED ARE:       9     10     11
NEXTSTEP=   13 BRFLGSTP=   13
LINK=   16 EXCRATE= 0.1500 COLUFLG= N
CRIT MAX FIN BAL OCC= 0.1500

**********************************************************


STEPID=   16 STEPTYPE= C STEPNAME=  EDIT CHK - EMP NO

ERRORS CONTROLLED ARE:       1      6      9
NEXTSTEP=   17 BRFLGSTP=   19
LINK=   17 EXCRATE= 0.0500 COLUFLG= N
CRIT MAX FIN BAL OCC= 0.0800

**********************************************************


STEPID=   17 STEPTYPE= C STEPNAME=  EDIT CHK - HRS OR RATES

ERRORS CONTROLLED ARE:       2      7     10
NEXTSTEP=   18 BRFLGSTP=   19
LINK=   18 EXCRATE= 0.3000 COLUFLG= N
CRIT MAX FIN BAL OCC= 0.0100
```

Figure A-2. Control Step Specifications.

```
*****************************************************************

STEPID=  18 STEPTYPE= C STEPNAME=  EDIT CHK - BATCH TOT

ERRORS CONTROLLED ARE:       8     11
NEXTSTEP=  19 BRFLGSTP=  19
LINK=  22 EXCRATE= 0.0010 COLUFLG= N
CRIT MAX FIN BAL OCC= 0.0100

*****************************************************************

STEPID=  22 STEPTYPE= C STEPNAME=  HASH TOT CHK

ERRORS CONTROLLED ARE:      21
NEXTSTEP=  23 BRFLGSTP=  25
LINK=  24 EXCRATE= 0.0500 COLUFLG= N
CRIT MAX FIN BAL OCC= 0.1000

*****************************************************************

STEPID=  24 STEPTYPE= C STEPNAME=  EMPLOYEE REVIEW

ERRORS CONTROLLED ARE:       1      2      6      7      9     10
NEXTSTEP=  25 BRFLGSTP=  25
LINK=   0 EXCRATE= 0.6500 COLUFLG= N
CRIT MAX FIN BAL OCC= 0.7500

***END OF CONTROL LIST***
```

Figure A-2 (Continued).

APPENDIX A-3

```
***THE IC SYSTEM HAS THE FOLLOWING BRANCH STEPS:

************************************************

STEPID=    4 STEPTYPE= B STEPNAME=  BR FOR TIME REC CORR
NO BR STEPNO=    6 BR TO STEPNO=    5

************************************************

STEPID=   13 STEPTYPE= B STEPNAME=  BR FOR KEYPUNCH CORR
NO BR STEPNO=   15 BR TO STEPNO=   14

************************************************

STEPID=   19 STEPTYPE= B STEPNAME=  BR FOR EDIT ERR
NO BR STEPNO=   21 BR TO STEPNO=   20

************************************************

STEPID=   25 STEPTYPE= B STEPNAME=  BR FOR TX CORR
NO BR STEPNO=    0 BR TO STEPNO=   20

*** END OF BRANCH LIST***
```

Figure A-3. Branch Step Specifications.

VITA

Casper Eldredge Wiggins, Jr., son of Virginia M. and Casper E. Wiggins, was born on May 7, 1949 in Charleston, South Carolina. He attended public schools in Greenwood, South Carolina and was graduated from Greenwood High School in May 1967. In September 1967 he enrolled at Wofford College in Spartanburg, South Carolina and completed the requirements for a Bachelor of Arts degree in Economics in May 1971.

After a tour of active duty with the United States Air Force Reserve, he entered the Graduate School at the University of Georgia in September 1972. He received the Master of Business Administration degree with a major in accounting from the University of Georgia in August 1974. In October 1974 he accepted a position as a staff accountant with Arthur Andersen & Co. in Atlanta, Georgia. In May 1975 he entered the Graduate School, College of Engineering, at Clemson University in Clemson, South Carolina. He joined the faculty of the Department of Accounting, College of Industrial Management and Textile Science, at Clemson University in August 1976 and served as a visiting instructor until May 1978. He received the Master of Science degree in Systems Engineering at Clemson University in August 1978.

He enrolled in the Graduate School at The University of Tennessee, Knoxville in September 1978 and received the Doctor of Business Administration degree in March 1982. He is a member of the American Accounting Association, the National Association of Accountants, and Phi Kappa Phi Honor Society.

He is married to the former Connie Mylinda Segars of Carnesville, Georgia.