A METHOD FOR MANAGEMENT OF INTERNAL AUDIT RESOURCES IN MULTI-LOCATION MILITARY AUDITS

Thesis for the Degree of Ph. D.
MICHIGAN STATE UNIVERSITY

JIMIE KUSEL
MAJOR, USAF

1972

This is to certify that the

thesis entitled

A METHOD FOR MANAGEMENT OF INTERNAL AUDIT RESOURCES
IN MULTI-LOCATION MILITARY AUDITS

presented by

Jimie Kusel
Major, USAF

has been accepted towards fulfillment
of the requirements for

Ph.D. degree in Accounting

Gardner M. Jones

Major professor

Date Dec 8, 1972

O-7639

ABSTRACT

A METHOD FOR MANAGEMENT OF INTERNAL AUDIT RESOURCES IN MULTI-LOCATION MILITARY AUDITS

By

Jimie Kusel
Major, USAF

Over the past several years the need to find more efficient internal audit methods has become increasingly serious. Department of Defense internal audit staffs have been reduced relative to the size of the internal audit workload. This pattern of a diminishing auditor staff concurrent with an expanding internal audit workload has become a matter of serious concern to the Air Force Audit Agency, the primary organization of interest.

The research concerned an analysis of internal audit reports completed by the Air Force Audit Agency. The primary purpose was to determine a method or methods by which the information contained in the reports of audit can be produced more economically. Although the methods were developed from empirical data provided by the Air Force

Over

efficient i

serious. I

been reduce

workload.

concurrent

become a

Agency, t

T

reports

many pur

the ins

produce

develop

ABSTRACT

A METHOD FOR MANAGEMENT OF INTERNAL AUDIT RESOURCES IN MULTI-LOCATION MILITARY AUDITS

By

Jimie Kusel
Major, USAF

Over the past several years the need to find more efficient internal audit methods has become increasingly serious. Department of Defense internal audit staffs have been reduced relative to the size of the internal audit workload. This pattern of a diminishing auditor staff concurrent with an expanding internal audit workload has become a matter of serious concern to the Air Force Audit Agency, the primary organization of interest.

The research concerned an analysis of internal audit reports completed by the Air Force Audit Agency. The primary purpose was to determine a method or methods by which the information contained in the reports of audit can be produced more economically. Although the methods were developed from empirical data provided by the Air Force

udit Agency

that organiz

other multi-l

environment.

Much

called infor

curves measu

tion (called

tional locat

where statis

to certain

curves can b

auditing dec

Four

1.

2.

Audit Agency and are therefore of direct applicability to that organization, the methods should be of interest to other multi-location organizations operating in a similar environment.

Much of the discussion centers around what are called information derived curves. In simple terms, these curves measure the accumulation of new items of information (called reportable type items) provided by each additional location included in an audit. It is argued that where statistical techniques cannot be adapted economically to certain internal audit tasks, the information derived curves can be used to provide quantitative data for making auditing decisions.

Four basic hypotheses were advanced:

1. The first few locations in a judgmentally selected sample of locations make relatively large contributions to the total amount of information derived from the audit.
2. The information derived curve developed from a judgmental selection of individual audit locations is significantly superior to such curves developed from a random selection of locations.

3. The information derived curve can provide an internal audit management tool, the use of which can result in more efficient use of internal audit resources.
4. There is a range of locations for a given audit beyond which the incremental cost of audit tends to exceed the value of the incremental information.

The research was directed toward confirmation or refutation of each of these hypotheses. Although the obtainable evidence was not of such nature to "prove" that an hypothesis is true or not true, the preponderance of evidence was sufficient support to accept each proposition. The evidence was gathered from a detailed analysis of sixteen subject matter audit reports that summarized information from more than 1600 individual reports of audit, and by interview with audit managers directly and indirectly associated with these audits.

The dissertation is organized into eight chapters. Chapters I and II provide general background to the research area and introduce the reader to the military environment in which the research took place and for which the suggested audit methods were developed. Chapters III and IV revie

nomical rang

cussed and t

determined.

improving t

stemming fr

Chapter V di

ture in de

attention.

the manageme

Chapter VII

mented audi

extent to w

and IV review the details of the research. Here the economical range of locations to use in each audit is discussed and the shape of the information derived curve is determined. Chapters V-VII discuss specific methods for improving the management of internal audit resources stemming from the research results provided. Specifically, Chapter V discusses the use of the information derived curve in determining management areas in need of audit attention. Chapter VI discusses the use of the curve in the management of the field test of new audit programs. Chapter VII discusses a new audit technique called the segmented audit. The last chapter, Chapter VIII, reviews the extent to which the hypotheses proposed were confirmed.

A METH

In

Departm

A METHOD FOR MANAGEMENT OF INTERNAL AUDIT RESOURCES IN MULTI-LOCATION MILITARY AUDITS

By

Jimie Kusel
Major, USAF

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Accounting and Financial Administration

1972

To my father and mother,

Henry and Juanita Kusel

I a

guided and

He was chai

motivator t

bution has

a small tok

other member

Dr. Maryell

this disser

and interes

I w

General Har

Mr. Trento

permission

Adult Agen

friends wi

greatly a

I

Jo McKenzi

ACKNOWLEDGMENTS

I am especially indebted to Dr. Gardner Jones who guided and maintained a very active interest in my work. He was chairman of the Dissertation Committee, advisor, motivator to greater achievement, and friend. His contribution has been invaluable and this acknowledgment is only a small token of my appreciation for his efforts. The other members of my committee, Dr. Bruce Coleman and Dr. Maryellen McSweeney also contributed significantly to this dissertation. Their comments, criticisms, suggestions, and interest were greatly appreciated.

I would like to express my appreciation to Major General Harold C. Teubner, The Auditor General, and to Mr. Trenton D. Boyd, Deputy Auditor General, for their permission to accomplish the research within the Air Force Audit Agency. A special thanks is also due to my many friends within that agency whose assistance and cooperation greatly aided completion of the research.

I would also like to express my appreciation to Jo McKenzie for the outstanding job of typing the

manuscript.

were invalua

completed di

Fina

edge is that

the real cos

For almost a

professional

some degree

stood beside

wherever p

manuscript. Her speed, accuracy, and attention to detail were invaluable in permitting the timely submission of the completed dissertation.

Finally, the greatest debt that I wish to acknowledge is that owed to my wife Janet. She alone knows what the real costs of this dissertation and degree have been. For almost all of our married life I have been enrolled at professional Air Force schools or involved in working on some degree at some college. Yet, through it all she has stood beside me, encouraging and assisting whenever and wherever possible. To her, my most loving thanks.

TABLE OF CONTENTS

Chapter

Chapter		Page

LIST OF TABLES

Table

16. Re
Le

17. Co

18.

19.

20.

21.

22.

23.

24.

25.

26.

27.

28.

29.

30.

Table

Cur
Typ
Pha

Ave
Inf
Pha

is

Pe

LIST OF FIGURES

Figure		Page

Thi

sidered acc

ditions, o

tions have

The

research p

management

resources.

applicabi

private m

similar c

T

reader to

tions dis

and the n

section,

more shar

tified sp

CHAPTER I

INTRODUCTION

Time changes many things. Management methods considered acceptable in former years are, under present conditions, often found inadequate. New research and innovations have thrown the old methods out of perspective.

The same is true for internal auditing. This research proposes new considerations specifically for the management of United States Air Force (USAF) internal audit resources. These proposals, however, should have general applicability to other Department of Defense (DOD) and private multi-location organizations operating under similar conditions.

The purpose of this chapter is to introduce the reader to the research. Accordingly, the first two sections discuss general DOD internal audit responsibilities and the nature of the internal audit product. The third section, called The Economics of Sampling, begins to focus more sharply on the central area of interest which is identified specifically in the following section. The background and general approach that is taken in the research is followed by a succinct statement of the purpose of the research, identification of the research parameters, and a listing of the four basic hypotheses of the study. The first chapter concludes with a brief overview of the remaining chapters to provide the reader with a roadmap to lead him through the balance of the discussion.

DOD Internal Audit Agency Responsibility

Although many Americans consider themselves well acquainted with their Department of Defense Armed Services, relatively few, even among those who have served within those Services, are aware of the full range of its activities.

The national significance of Armed Services activities is such that their importance really cannot be measured in common business terms, but they do involve aspects that are susceptible to business measurement. Some of these activities are very large even when compared with the industrial giants of our nation. For example, Air Force assets alone total approximately 85 billion dollars. This is greater than the combined assets of the top 50 manufacturing firms of this nation.[1]

The support necessary for maintaining Department of Defense readiness includes large and varied activities found only

cial enter

embraces s

tion, mark

diversity

which bec

agencies.

Th

purpose o

ment . .

evaluatio

manageri

ational,

To fulfi

seek be

keep pa

effici

seriou

relat

patte

expa

seri

orga

found only in combinations of major industrial and commercial enterprises. The range of diversified activities embraces such dissimilar fields as warehousing, transportation, marketing, and communications. This exceptional diversity adds to the problems of management, problems which become the direct concern of the DOD internal audit agencies.

These internal audit agencies are charged with the purpose of providing . . . "those responsible for management . . . with an independent, objective, and constructive evaluation of the effectiveness and efficiency with which managerial responsibilities (including financial, operational, and support activities) are being carried out."[2] To fulfill this obligation, these agencies must continually seek better ways to produce information and advice and to keep pace with management's needs.

Over the past several years the need to find more efficient internal audit methods has become increasingly serious. DOD internal audit staffs have been reduced relative to the size of the internal audit workload. This pattern of a diminishing auditor staff concurrent with an expanding internal audit workload has become a matter of serious concern to the Air Force Audit Agency, the primary organization of interest in this dissertation. In the three year

personnel

and there

During th

cumulativ

been no s

tions at

F

only a fi

to the pr

should re

They sho

The car

terms of

the pur

three years ended June 30, 1971, Air Force Audit Agency personnel authorizations declined approximately 22 percent, and there is no reason to expect a reversal in this trend. During this same period Air Force resources grew both in cumulative inventory and annual consumption. There has been no significant reduction in the number of major locations at which the Air Force operates.

Recognizing a problem, serious as it may be, is only a first step toward finding and adopting a solution to the problem. Recommended changes in audit methods should meet at least the following very general criteria. They should be:

1. based as completely as possible on objective rather than subjective considerations.
2. designed to assist the audit agency to meet the objectives specified by governing Department of Defense and Air Force instructions, regulations and policies.
3. effective in providing operating managers the type of information that will help them do a better job of managing.

One cannot evaluate a proposal for a new audit method in terms of these criteria without a thorough understanding of the purpose and the product of internal audit agencies.

As

agencies i

and effici

being carr

on Air For

Stated and

product?

It

Force int

audit cre

for the a

for audi

tive ver

need for

It is t

audit e

is a ce

is in

of the

As stated above, the purpose of internal audit agencies is to provide an evaluation of the effectiveness and efficiency with which managerial responsibilities are being carried out. Narrowing attention more specifically on Air Force internal audit, how is this purpose achieved? Stated another way, what is the Air Force internal audit product?

The Internal Audit Product

It is possible to justify the existence of Air Force internal auditing by pointing to the requirements for audit created by law. However, this is totally artificial, for the auditing organization exists because a need exists for auditing services. In terms stripped of formal directive verbosity, Air Force internal auditing satisfies a need for information of two types:

1. Information for management decision-making.
2. Information on management performance.

It is this information that is the product of the internal audit effort.

The method of deriving this internal audit product is a central focus of this research. Evaluation of method is in turn dependent upon an understanding of the use made of the information. Both the method of deriving information

and the us
quent chap
with the a
able at th
ternal au
organizat

I

mander is
ized prof
ference i
resource -
resources
commander
in order
informati

T

intereste
sions, b
assist i
Thus, th
informat

decision
ment, an

and the use of information are discussed at length in subsequent chapters. For purposes of acquaintaing the reader with the area of research, however, it is probably advisable at this point to touch briefly upon the use of internal audit information in the context of the military organizational structure.

It makes some sense to view the military base commander as in a position analogous to that of the decentralized profit manager in the commercial enterprise. The difference is simply that the base commander is a decentralized resource manager concerned with the optimum utilization of resources rather than with profit generation. The base commander needs specific information on resource utilization in order to improve his managerial effectiveness. He needs information to assist him in making decisions.

Top management (management above base level) is interested in information that can be used to make decisions, but it is also interested in information which will assist in measuring the performance of the base commander. Thus, two types of information are needed from an audit, information <u>for</u> management and <u>about</u> management.

The experienced auditor realizes that different decisions are made by the base commander and top management, and different information is needed by each of these echelons.

frequentl

dealing wi

commander

system we

locations

R

mation ne

tive sta

resources

interest

level pr

that a

given b

determ

base c

reveal

measur

mater

does

nearl

mana

are,

echelons. However, the information needed at base level is frequently useful also to top management. Audit findings dealing with base performance not only assist the base commander in his mission, but also inform top management of system weaknesses and of potential problem areas at other locations.

A very important point emerges from this dual information need. The base commander may wish to have quantitative statements about any discrepancies dealing with the resources under his command; top management is much less interested in specific quantitative inferences about base level problems. It is usually sufficient for them to know that a significant problem area exists.[3]

Hence, with regard to audit programs applied at a given base, the auditor may wish to use statistically determined and applied sampling plans. This is because the base commander desires to have information which not only reveals that a problem exists, but additional data permitting measurements of how material the problem is and how its materiality is changing over time. However, top management does not need quantitative measurements of difficulties nearly as frequently as does the base commander. Top management needs to know what the significant problems are, what the likely causes of the problems are, and what corrective

situation.

E

provide in

management

any manag

as origin

management

A

tion, suc

answers t

management

to here a

plished f

ficient

organiza

audits w

It is wi

is prima

for aud

organiz

for exa

Until

corrective action in the system is needed to remedy the situation.[4]

Each internal audit accomplished is not required to provide information to both base level and top levels of management. Requests for audit service can originate at any management level. It is convenient to think of audits as originating from two basic levels--base level and top management level.

Audits requested by and confined to a single location, such as a base, are primarily designed to provide answers to specific questions of particular concern to management at that location. These audits will be referred to here as <u>local audits</u>. Audits requested by or accomplished for top level management must be applied at a sufficient number of locations within the multi-location organization to provide the information desired. These audits will be referred to as <u>centrally directed audits</u>. It is with the centrally directed audits that this research is primarily concerned.

Each of the armed services (Air Force, Army, Navy), for audit purposes, can be viewed as a multi-location organization. Auditable activities within the Air Force, for example, may be operated at approximately 180 locations. Until recently it was the policy to apply centrally directed

tions at

E

requires

tent nece

An all-in

manager,

needed to

audit com

managemen

audit eff

vide spec

the selec

are acco

then fre

popular

discusse

samplin

univers

procedu

directed audits concerning an activity at all of the locations at which that activity existed.

Efficient management of internal audit organizations requires the application of audit resources only to the extent necessary to derive the type of information required. An all-location application of an audit serves each base manager, but will likely provide more information than is needed to identify a problem area for top management. An audit completed at a sample of locations can provide top management adequate information and conserve the amount of audit effort that is centrally directed, but will not provide specific information to base managers not included in the selection.

Accepting the fact that centrally directed audits are accomplished by Air Force internal auditors, one is then free to consider methods of managing such audits. One popular method of generating audit information frequently discussed in the audit literature is to employ some type of sampling plan.

The Economics of Sampling

By applying these audits at a sample rather than a universe of locations the auditor must assume that such procedures have advantages. But what are they? Do aggregate

S

theoretic

indicates

desirable

at 120 lb

that the

of an aud

locations

butions

tests.

increases

increase,

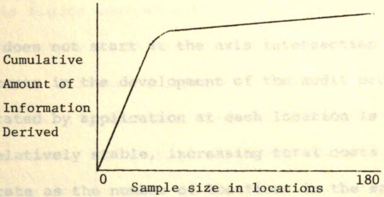
curve of

aggregate gains exceed losses?

Since information is the product of the audit, a theoretical study of auditing at a sample of locations indicates that a sampling method is at least economically desirable. Assume that a management system is in operation at 180 locations (or bases) worldwide. One can hypothesize that the curve of information derived from the application of an audit to test this system can be drawn as follows:

FIGURE 1

INFORMATION DERIVED CURVE



This figure simply indicates that the first few locations in any sample will make relatively large contributions to the amount of information derived from the audit tests. As the number of locations included in the sample increases, the total amount of information derived may increase, but at a decreasing rate.

From data provided by past statistical records, the curve of the cost for the development and applying the adins at

The curre

of fixed

Cost gene

sidered r

constant

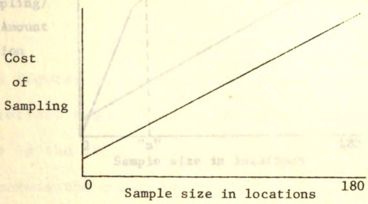
increase

bined wo

audits at locations can be drawn somewhat as follows:

FIGURE 2

COST OF SAMPLING CURVE



The curve does not start at the axis intersection because of fixed costs in the development of the audit program. Cost generated by application at each location is considered relatively stable, increasing total costs at a constant rate as the number of locations in the sample is increased.

One can now hypothesize that the two curves combined would provide the following figure:

Cost of S

Cumulat.

of Indir

Derived

tions in

constant

decreasin

the doll

the two c

size in

Total co

to perfo

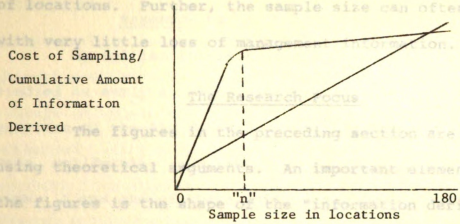
After al

performi

of Inde

FIGURE 3

RATIO OF COST TO INFORMATION DERIVED



This figure indicates that as the number of locations in the sample is increased, costs increase at a constant rate. Information derived increases, but at a decreasing rate. To maximize the amount of information for the dollars spent, the size of the sample should be where the two curves are farthest apart, or at point "n."

The auditor must not, however, believe that sample size "n" is a magic solution. While undoubtedly cost is a vital consideration confronting the auditor who has a test to perform, it should not be an overriding consideration. After all, the lowest cost of auditing is attained by not performing the test at all!

An important principle derived from this graph (if indeed the hypothesized information derived curve is accuratel

as the a

of locat

with ver

using th

the fig

curve,"

rather e

"informa

involves

of infor

units as

be estab

edge of

resourc

methods

while

of info

determi

accurately portrayed) is that costs will be avoided as long as the audit program is applied at less than the population of locations. Further, the sample size can often be cut with very little loss of management information.

The Research Focus

The figures in the preceding section are drawn using theoretical arguments. An important element within the figures is the shape of the "information derived curve." Whereas the curve for actual costs of auditing is rather easily determined, determining the shape of the "information derived curve" is a more difficult task. This involves not only defining items to be measured, the units of information, but a determination of how to measure such units as well.

Assuming that the "information derived curve" can be established, the important question becomes does knowledge of this curve aid in the management of internal audit resources? That is, does knowledge of this curve suggest methods for more economically abstracting audit information while maintaining acceptable levels of timeliness, quantity of information, quality of information, and cost.

The primary focus in this research was upon the determination of the shape of the "information derived curve" ar

use.

kindled

quarters

Base, C.

sion. I

audit wor

search o

such res

General

in

an

wit

gen

is

has

tion a

being

existe

that w

each b

tion t

curve" and upon the appropriate arguments that support its use.

Research Background and Approach

My initial interest in the research area was kindled as early as 1966-67 when I was assigned to the headquarters of the Air Force Audit Agency, Norton Air Force Base, California, as a member of the General Research Division. I was one of three individuals detached from routine audit work and given the task of conducting conceptual research on audit methodology. The importance attached to such research is reflected in the words of the then Auditor General of the Air Force, Major General Don Coupland:

> We constantly seek self-improvement. To aid in improving our audit methods, we established an Auditor General Research Division. Included within this division are personnel assigned to general research . . . The number of personnel is small . . . but the impact of their products has far reaching effects on the organization.[5]

At that time, audits designed to provide information about an activity to top levels of management were being applied at all of the locations at which that activity existed. But as stated earlier, one could reasonably argue that while an all-location application of an audit serves each base commander, it will likely provide more information than is needed to identify a problem area for top managemen

T

sistent r

of the pr

tain or

numbers

reflecte

managers

through

importan

Agency.

cussed i

three se

mation i

included

informat

of loca

three a

number

evident

appropr

Force A

locatio

management.

This reasoning, together with the reality of a consistent reduction in audit manpower brings one to the core of the problem. How can the Air Force Audit Agency maintain or even expand its service in the face of diminishing numbers of auditors? The seriousness of the problem is reflected time and again in the statements of top level managers (for examples of such statements see pages 38 through 40). My interest was, in turn, motivated by the importance attached to this area by the Air Force Audit Agency.

My earliest phase of the research, which is discussed in Chapter III, included the detailed analysis of three separate audits to determine how quickly audit information is accumulated as additional audit locations are included in the sample of locations. For each audit, information produced by 10, 20, 30, 60, and the universe of locations was evaluated. Although analysis of but three audits did not provide conclusive evidence as to the number of locations that should be included, it was clearly evident that some number less than the universe would be appropriate. Based upon this initial research, the Air Force Audit Agency decided to apply certain audits at 60 locations.

not fully
reason w
research
result o

research
which is
four aud
were rev
of infor
selected
which th
the "in
for the
that s
in dete
audit,
in the
quent
revise
it was
sharpe

But in my opinion the Air Force Audit Agency did not fully exploit the initial research findings. A basic reason was undoubtedly the lack of more comprehensive research to provide stronger evidence of the probable result of changing audit methods.

To provide this evidence my next phase of the research was initiated. In this phase of the research which is elaborated upon in Chapter III, the data from four audits originally applied at from 55 to 152 locations were reviewed. Particular attention was paid to the amount of information that was in evidence at 10 or less locations selected judgmentally from the population of locations at which the audit was applied. This research indicated that the "information derived curve" (refer to Figure 1, page 10) for the small number of locations has a distinctive shape that suggests several audit method improvements, not only in determining the number of audit sites to include in an audit, but for the detection of areas in need of audit and in the development of the necessary audit programs. Subsequent to this research the Air Force Audit Agency again revised their audit methods in line with the research, but it was evident that additional research was needed to sharpen the focus of these new methods.

After I became a doctoral student in mid-1970 the research

perform

area of

would be

records,

multi-l

made. W

approval

undertak

mation

limits

niques.

selecte

to indi

and to

ence be

method

of the

manage

have r

manage

selec

research to date was documented and a proposal prepared to perform additional research into this important management area of the Air Force Audit Agency. Although the research would be specifically within the Air Force Audit Agency records, the results should be of general interest to any multi-location organization at which internal audits are made. With the support of the Air Force Audit Agency and approval from my major professor, the current research was undertaken.

As detailed in Chapter IV, the shape of the "information derived curve" was determined within reasonable limits using both judgmental and random selection techniques. More specifically, nine subject matter audits were selected for detailed analysis. Nine is a sufficient number to indicate the shape of the "information derived curve" and to show that there is a significant statistical difference between the judgment method and the random selection method.

Considering first the judgmental method, for each of the nine subject matter audits, Air Force internal audit managers were asked to select 15 locations which they would have recommended had the audit been restricted. These managers were interviewed to determine the basis for the selection, ie., size of base, quality of audit staff at that location, representativeness of the auditable system at that location, etc. These locations were arrayed by the audit managers in an order of preference from 1-15.

The supporting records for the subject matter audit were reviewed to identify the reportable type items. Reportable type items for this research include those items which were found to be present at ten percent or more of the population of locations at which the complete subject matter audit was applied.

Each individual audit input from each location (in order of preference from 1 to 15) was analyzed for each of the nine subject matter audits. Reportable type items were identified and a cumulative "information derived curve" was constructed. The nine cumulative curves were plotted, with analysis made at the 5, 10 and 15 location points.

For the random selection method, the above research was duplicated with one exception. The 15 individual locations for each subject matter audit were selected randomly using random number tables.

The judgmentally and randomly derived curves were then compared and appropriate conclusions drawn.

Management uses of the information derived curve were then developed. The discussed uses consider such criteria as risk of nondetection of significant management in

produ

suggeste

of inform

derived c

tion of th

at the sam

determine

finding

the error

rate from

and, to e

location,

locations

I

derived c

internal

may be a

problems, the time required to achieve the subject matter report of audit, the cost in terms of audit hours, and the quantity and quality of the resulting management information. As elaborated upon in subsequent chapters, risk is a function of the "information derived curves." Timeliness is a function of the "reasonable" time requirements from inception of the audit to delivery of the final audit product. Costs are evaluated in terms of audit hour costs suggested for planning purposes by audit managers. Quantity of information, like risk, is a function of the "information derived curve". Finally, quality of information is a function of the materiality of the reportable type items found at the sample. Materiality, in turn, is judged by a predetermined measure. For example, to judge that the sample finding is as material as the finding from the population, the error rate must be equal to or greater than the error rate from the population of locations in the complete audit and, to ensure the information is not clustered at a single location, at least two of 5, three of 10, or four of 15 locations must indicate the problem.

It is argued that consideration of the "information derived curve" suggests a number of possibilities for internal audit cost savings. At times these cost savings may be at the expense of one of the other criteria we wish to maintai

informati

costs are

the number

matter a

assumed c

elaborate

to dete

curve

knowle

nomic

form

effe

ness

to maintain, such as timeliness, quantity, or quality of information. But what is of importance, these likely costs are now quantifiable. Judgments to expand or reduce the number of individual locations included in a subject matter audit can be based on known costs rather than assumed costs. Specific discussion of these points are elaborated upon in subsequent chapters.

Purpose

Stated succinctly, the purpose of this research was to determine the actual shape of the "information derived curve" and to demonstrate by appropriate argument that knowledge of the shape can provide an effective and economical management tool----a management tool that has not formally been considered. Criteria used in judging the effectiveness and economy of the proposals included timeliness, quantity, quality, and cost of information.

Research Parameters

This research was restricted to those audits accomplished by the Air Force Audit Agency. Although the investigative work was limited to Air Force audits, it is anticipated that the results will be of interest to other multilocation organizations.

A further limitation concerned the age of the

the
in
ri
audi
solic
assump
ating
the fut
provided
this res

information systems reviewed by audit. Since the bulk of the Air Force internal auditors work is concerned with what might be called "established systems," only audits completed on systems that have been in operation for at least a year were selected for detailed analysis.

Finally, no attempt was made to determine if the types of information provided to each management level as discussed earlier (pages 5-9) are the types of information that should be provided. The rationale for the types of information that are provided reflects the consensus derived from discussions with audit managers of the Air Force Audit Agency. Opinions of operating managers were not solicited. The present research was accomplished with the assumption that information that has been provided to operating managers in the past will continue to be provided in the future. A determination of what information should be provided to each level of management is beyond the scope of this research.

Four Basic Hypotheses

The following four basic hypotheses are advanced:

1. The "information derived curve" is uniquely shaped. That is, the first few locations in any sample will make relatively large

contributions to the total amount of information that is derived from the subject matter audit. As the number of locations included in the sample increases, the total amount of information derived may increase, but at a decreasing rate.

2. The "information derived curve" developed from a judgmental selection of individual audit locations is significantly superior (α=.10) to such curves developed from a random selection of individual audit locations.
3. There is a minimum number or at least a range of locations for a given audit for which audit cost can be considered reasonable. Beyond that range the incremental cost of audit tends to exceed the value of the incremental information.
4. The "information derived curve" can provide an internal audit management tool, the use of which can result in more efficient use of internal audit resources.

General Organization

This concluding section provides the reader a road-map to lead him through the balance of the discussion to include insight into both structure and content of each chapter.

Chapter II provides a brief discussion of the Air Force Audit Agency organizational structure and of its product -- the audit report. The purpose is to illustrate the environment in which the research is accomplished and to aid the reader in drawing similarities between this multi-location audit agency and any other multi-location organization of interest.

Chapter III presents the initial effort to define the individual units of information that compose the "information derived curve" and the results of preliminary research to determine the shape of the curve. Changes initiated in audit methods by the Air Force Audit Agency subsequent to this early research are reviewed briefly.

Chapter IV provides a comprehensive discussion of the research to determine the actual shape of the "information derived curve." Nine audits, each of which was applied at 40 or more locations, are analyzed. Both judgmental and random selection techniques are used to develop "information derived curves" for a limited number of locations selected from each audit. The judgmental and random selection techniques are compared and evaluated.

Chapters V, VI, and VII explore additional methods by which knowledge of the "information derived curve" can be used for more economically abstracting audit information. More specifically, Chapter V discusses application of the knowledge to determining areas in need of audit attention, Chapter VI to the audit program field test situation, and Chapter VII to the segmented audit.

Chapter VIII concludes with a discussion of the initial hypotheses of the research.

4. See

5. *Ibid.*

FOOTNOTES

1. Major General Don Coupland, "Current Management -- An Audit Challenge," The Armed Forces Comptroller, April, 1967, p. 23.

2. Department of Defense Directive No. 7600.2, Department of Defense Audit Policies. Washington, D.C.: Department of Defense, 19 August 1965.

3. This was the general consensus of Air Force audit managers charged with the responsibility of briefing top level Air Force managers on the results of internal audits. Based partly upon this belief of what information managers need, a decision was made within the Air Force Audit Agency to apply certain audits at less than the population of locations. No attempt is made in this research to evaluate user needs for this information.

4. See note 3.

5. Ibid., p. 24.

or any p

auditor

report t

action.

he can c

where th

reader a

was acc

may be

between

other m

section

followe

quarter

chapter

approach

CHAPTER II

THE AIR FORCE INTERNAL AUDIT ENVIRONMENT[1]

When supply lines snarl, cash balances collapse, or any phase of management malfunctions, the Air Force auditor is the man on the spot to uncover the trouble and report to the level that can take the necessary corrective action. He is stationed as close by as possible to where he can offer the greatest service. He lives and works where the Air Force lives and works.

The purpose of this chapter is to provide the reader a glimpse of the environment in which the research was accomplished. By understanding that environment, it may be easier to ascertain similarities and differences between operating methods of the Air Force Audit Agency and other multi-location organizations of interest. The first section traces the history of the organization. This is followed by a brief discussion of the organizational headquarters and the separate line and staff elements. The chapter concludes with a capsulized review of the audit approach and of the final product, the audit report.

separate

ending 4

States A

the audi

taries o

responsi

sibility

Air Forc

of the (

less of

of the

Auditor

cally

August

indepe

effici

carrie

Opera

tive

the

When Air Force Audit Was Born

The United States Air Force was established as a separate department by the National Security Act of 1947--ending 40 years of Air Force association with the United States Army. The Army Audit Agency continued to perform the audit function until, by agreement between the Secretaries of the Army and the Air Force, the Air Force assumed responsibility for its own audit function. The responsibility was assumed on 1 July 1948 when the United States Air Force (USAF) Auditor General was established as a part of the Comptroller. Today, all Air Force auditors, regardless of where they are located, are part of the Comptroller of the Air Force and are directly responsibile to the USAF Auditor General.

The responsibility for internal audit was specifically set forth in the National Security Act Amendments of August 1949. As defined by the DOD, internal audit is the independent review and evaluation of the effectiveness and efficiency with which managerial responsibilities are being carried out. It is an independent appraisal of financial, operational, and support activities as a basis for protective and constructive service to management.

It is a service to all levels of management, from the smallest based-situated organization up through major command t

the neces

is author

Assistant

ment.

<u>Air</u>

Auditor

visory a

mately

Force i

at majo

almost

direct

Force

format

bases.

audit

orient

they

manag

command to the top levels of the Air Force. To maintain the necessary independence of review, the Auditor General is authorized to use direct lines of communication with the Assistant Secretary of the Air Force for Financial Management.

Air Force Audit Agency Headquarters-Line and Staff

At the Norton Air Force Base headquarters, The Auditor General of the Air Force and his staff of supervisory and support personnel furnish guidance to approximately 1100 professional auditors located at major Air Force installations throughout the world.

Having resident auditors and their staffs located at major Air Force installations around the world allows almost immediate response to Air Force-wide problems. By directing audit effort from the headquarters at Norton Air Force Base, California, the Auditor General can gather information on any type of activity at any or all Air Force bases. Consolidated reports are prepared to communicate audit results to the highest levels of Air Force management.

Air Force auditors, increasingly management-oriented, are not confined to reporting the discrepancies they uncover but dig into problem causes in order to furnish management with recommendations leading to greater operation

is wrong,

has faile

be done

of the o

aligned

staff an

was to p

create

sibilit

organiz

office

his ci

assign

Comptr

positi

Force

the A

Associ

office

Air S

timel

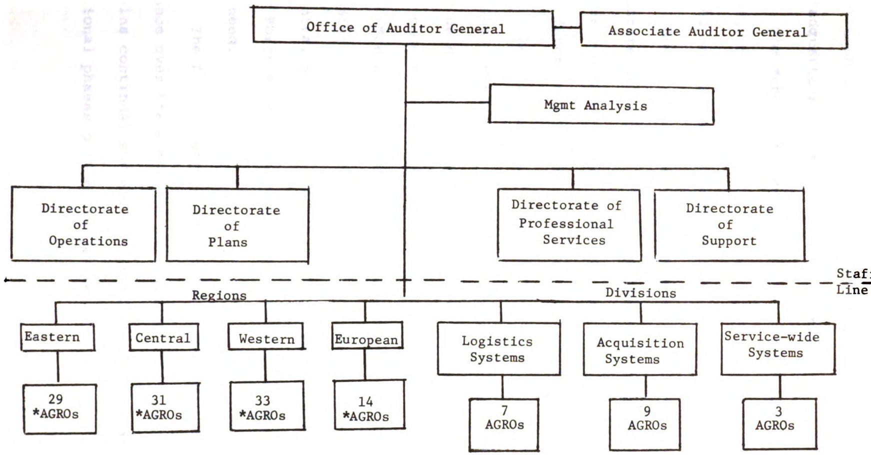
operational efficiencies. Auditors not only determine what is wrong, but also why a method, directive, or procedure has failed, the impact it may have, and what might possibly be done to correct it.

Early in July 1968, the functional responsibilities of the organizational elements at the headquarters were realigned to establish an unequivocal distinction between staff and line functions. The purpose of this realignment was to provide for a more homogeneous grouping, and to create staff elements which have mutually exclusive responsibilities. Figure 4 gives a concise picture of the present organization.

Beginning at the top of the organization chart, the office of The Auditor General is staffed by a Major General, his civilian deputy, and his executive officer. The assigned general officer fills a tri-position as Assistant Comptroller for Audit (an Air Force Headquarters staff position), as The Auditor General, and as Commander--Air Force Audit Agency. Because of the distance separating the Auditor General headquarters and Washington, D.C., an Associate Auditor General and staff maintain permanent offices in the Pentagon. These personnel can contact the Air Staff and other Pentagon-based officials in direct and timely communication for The Auditor General. The Associate

FIGURE 4

AIR FORCE AUDIT AGENCY - ORGANIZATION CHART



*Some AGROs supervise one or more operating locations.

Auditor

the Hea

pendent

critica

Direct

manpow

sonnel

conce

caree

tiona

devel

for c

of A

addi

Well

main

Oper

Auditor General and personnel of his office are assigned to the Headquarters, United States Air Force.

The Management Analysis Office, functioning independently of staff or line, serves all elements with a critical analysis of management data.

Among staff elements of the headquarters, the Directorate of Support provides general administration, manpower and budget functions, military and civilian personnel functions, and data automation.

The Directorate of Professional Services conducts conceptual research on audit methodology, training and career development, and formulates and documents organizational objectives and policies.

The Directorate of Plans takes responsibility for developing comprehensive audit plans. These plans provide for centrally directed audit effort and continuing reviews of Air Force systems, programs and projects to determine audit need.

The Directorate of Operations provides staff surveillance over the execution of approved audit plans and maintains continual surveillance over all significant operational phases of the line elements.

ations

region

aries f

ating t

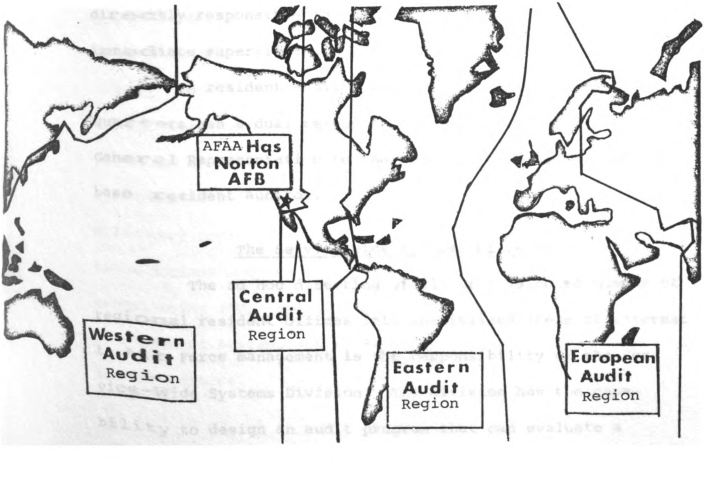
Residen

The Regions--Geographic Slices of The World

Audit responsibility for world-wide Air Force operations is divided into regions, as shown in Figure 5. Each region is established on the basis of geographical boundaries for the purpose of supervising, assisting, and evaluating the work of the Auditor General Representative or Resident Offices within that region.[2]

FIGURE 5

AIR FORCE AUDIT AGENCY REGIONS



located

of the C

Base, Te

Langley

pearl Pe

compose

auditor

tenants

all loc

direct

immedi

Quarte

Genera

base r

regio

to Ai

Vice-

Bill-

Supervisory personnel of the Western Region are located at Norton Air Force Base. Supervisory personnel of the Central Region are located at Carswell Air Force Base, Texas; those of the Eastern Region are located at Langley Air Force Base, Virginia; and those of the European Region are located at Lindsey Air Station, Germany.

A typical Auditor General Representative Office is composed of five to seven auditors, headed by a resident auditor as the office chief. These auditors are always tenants on the base with which identified, independent of all local commanders, and are, regardless of location, directly responsible to The Auditor General through their immediate supervisors.

A resident auditor located at a major command headquarters has a dual responsibility--he is the Auditor General Representative to the major command as well as the base resident auditor.

The Service-Wide Systems Division

The ad hoc directing of all or a selected number of regional resident offices into specialized areas of interest to Air Force management is the responsibility of the Service-Wide Systems Division. The division has the capability to design an audit program that can evaluate a manageme

ment as w

on the s

manageme

agement

intra-re

audit a

broader

a singl

audits

sult fr

select

sible

locate

System

Milita

techn

proce

manag

these

management system vertically through all levels of management as well as horizontally across numerous organizations on the same level. Integrated audits performed on selected management systems are designed to focus on not only management at several levels, but also the system's inter- and intra-relationships.

This division provides a tool for making in-depth audit analysis of management areas, analyses which are much broader in scope than would be possible from the effort of a single team of auditors at a given Air Force base. Such audits are called centrally directed audits since they result from programs developed by this division and sent to selected field offices for accomplishment.

The Service-Wide Systems Division is also responsible for three unique representative offices. One is located at each of the following Air Force centers: Data Systems Design Center, Accounting and Finance Center, and Military Personnel Center. The offices are staffed with technicians who are engaged in auditing automatic data processing (ADP) systems under development and the other management systems under the responsibility of each of these centers.

Patter

Logis

This

singl

handl

uniq

with

the

assi

in t

tem

dem

Sys

maj

Con

Sys

suc

at

Logistics--The AMA Approach

The Logistic Systems Division is located at Wright-Patterson Air Force Base, Ohio. Like the regions, the Logistic Systems Division has full-time auditors assigned. This special audit division was established to service a single major command because of the high value of resources handled by the Air Force Logistics Command (AFLC) and the uniqueness of the management systems employed. Auditors with specialized training and experience in logistics man the resident offices at the Air Materiel Areas (AMAs) to assist management in uncovering and correcting difficulties in the world-wide logistics functions. As with other system design centers, a large group of auditors are in residence with AFLC's Advanced Logistics Systems Center.

Acquisition Systems Division

Like the Logistic Systems Division, the Acquisition Systems Division is co-located with the headquarters of a major command--in this instance, the Air Force Systems Command at Andrews Air Force Base.

Auditors under the direction of the Acquisition Systems Division are assigned to the major buying centers such as the Space and Missile Systems Organization (SAMSO) at El Segundo and at Norton Air Force Base, California.

sibilit

approac

schedu

base,

his ti

tion a

ment.

initia

check

and p

manag

priat

a dra

repor

comm

in t

of t

ness

reco

unde

The Audit Report--A Final Product

Within this organizational framework, audit responsibility regardless of the auditor's location is basically approached in two principal manners, one, through locally scheduled audits, and two, through centrally directed audits.

In the first instance, the resident auditor on a base, when not occupied in performing directed audits, uses his time to identify audit needs peculiar to his installation and where, in his opinion, he can best serve management. He surveys areas of suspected audit need on his own initiative or in response to requests of local officials, checks out potential problem situations, develops a program, and performs the audit. He issues his audit report to the management level with the authority to assure that appropriate action is taken on audit findings and recommendations.

To follow the usual procedure, the auditor prepares a draft report of audit and discusses the contents of the report with base operating officials--possibly the activity commander and key section personnel whose work was reviewed in the audit--and with the installation commander. Purpose of the discussion is to insure that all management weaknesses uncovered during the audit are known and that recommended actions contained in the report of audit are understood.

and si

manage

the ma

analy

taken

that

other

hand,

provi

level

needs

funct

funct

polic

manag

is tr

tions

inclu

the p

the r

tary

Following the discussion, the report is finalized and signed by the resident auditor. Copies are provided to managers at base level, with a copy being sent directly to the major command concerned. The major command, after analyzing the report, may direct that specific actions be taken throughout the command--if there is a possibility that the management weaknesses noted may be in evidence at other command bases.

The centrally directed audit approach, on the other hand, is used to evaluate total resource management and to provide recommendations for systems improvement to top level Air Force decision-makers. Depending on management's needs, a centrally directed audit may be aimed at a specific functional problem; at an interrelationship of two or more functional activities such as maintenance and supply; at policies, procedures, and methods at several levels of management; or at an entire system where the total system is treated as one entity, considering all affecting functions, management levels, and interrelationships.

The results of these audits are summarized and included in Summary Reports of Audit which are issued to the Air Staff. Air Staff comments are incorporated into the reports which are transmitted to the Assistant Secretary of the Air Force for Financial Management and, by decre

offic

value

serie

At th

for a

sider

propo

in au

of aud

mande

follo

Strate

D
st
R
I
th
fr

Th
ar
ma
to
es
vi

decree of the Office of the Secretary of Defense, to the Office of the Assistant Secretary of Defense (Comptroller).

An Evaluation of the Service

That internal audit service is of considerable value to operating Air Force commanders is evident in a series of letters written by such commanders in early 1971. At that time, motivated by a consistent loss of manpower for a number of years, the Air Force Audit Agency was considering a proposal to reconfigure the organization. This proposal was apparently viewed as a step toward reduction in audit service.

In support of maintaining at least the same degree of audit service, Lieutenant General David C. Jones, Commander, Second Air Force, on January 28, 1971 wrote the following to General Bruce K. Holloway, Commander in Chief, Strategic Air Command:

> During the past year I have made it a point to stop and visit with the Resident Auditor supporting each of my bases. Without exception, I have been impressed with the qualities of these people and the positive results we get from the service they perform.
>
> The products and advice of the Resident Auditor are an essential and integral part of the command function throughout Second Air Force. With today's money and manpower reductions and the escalating cost of operations this service is vital if we expect to do more with less.

> I understand there may be some thought of reducing the number of Resident Auditors throughout the Air Force. If such an action takes place I believe it would be counter-productive. It would take an enormous savings to balance-out the loss of any of this small group of professional critics.

On January 29, 1971, Lieutenant General Paul K. Carlton, Commander, Fifteenth Air Force, on the same subject wrote:

> I recommend that resident auditor forces be retained and that the highest priority on the available services be given requests for audits of activities that numbered Air Force commanders consider to be of prime importance.

In response to these letters, General Holloway, on February 16, 1971, in a letter to General John D. Ryan, Chief of Staff, United States Air Force, stated:

> During the past year my immediate staff had occasion to review numerous audit reports issued to bases within SAC. Without exception, the quality of these reports and the positive results subsequently accrued, reflected the competence and positive attitude of resident auditors assigned. With the continuing budgetary and manpower reductions coupled with rising costs and increasing resource restraints, the products and advice of on-base resident auditors are an essential and integral part of management throughout SAC.
>
> I believe it would be counter-productive if the proposal to regionalize and reduce the resident auditors is implemented. Considerable savings would have to be realized to compensate for the loss of these professional people.

Finally, on March 4, 1971, General William W. Momyer, Commander, Tactical Air Command, wrote:

> In the past our sister services have been exposed to public criticism for internal management problems more often than has the Air Force. The constant presence of on-base auditors and their responsiveness to management needs has undoubtedly contributed to the Air Force's effort to effectively control and use available resources.

But desire for a service and ability to provide the service in the quantity desired do not always coincide. In the face of manpower reductions it becomes a constant challenge to generate the supply of service to approximate its demand.

Keeping Up With The Challenge-Research

Times have a way of changing and the organization must keep pace. Through research the old ways, the old procedures are often found inadequate under present conditions. New methods are found to improve audit service.

And so it is with the present research. Rather than accepting past methods of extracting information by audit, these methods were questioned and research support provided to suggest a better way.

FOOTNOTES

1. This chapter is based on an article written by Jimie Kusel, "Man-On-The-Spot", The Armed Forces Comptroller, July, 1969, pp. 22-26.

2. For definitions of these offices see page 47.

the

div

rat

duo

der

to

pha

cri

sec

the

res

of

boy

dis

res

of

CHAPTER III

RESEARCH -- PHASE I AND II

The primary purpose of this chapter is to review the first two phases of the research. The chapter is divided into four sections. The first section reviews the rationale for auditing at a sample of locations to reintroduce the primary subject of inquiry -- the information derived curve. The second section provides key definitions to terms used throughout the research, identifies the phases of research that were accomplished, and lists the criteria used to evaluate research results. The final two sections provide a discussion of the first two phases of the research. Covered by discussion for each phase of the research are: the objective or objectives, a description of what was measured, a description of the selection of both audits and audit locations used in the analysis, a discussion of the research and an evaluation of the results, actions taken by audit managers, and a discussion of the research to follow.

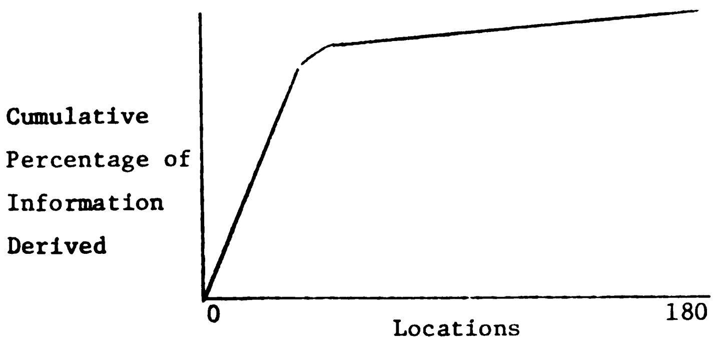
The Sampling Rationale

As pointed out in Chapter I, one can reason that auditing at a sample of locations rather than at the full population of locations is at least economically desirable. Since this rationale is basic to the following research, these arguments are briefly reviewed.

It was assumed that a management system is in operation at approximately 180 locations -- the universe of such locations. It was hypothesized that the curve of information derived from the application of an audit to test this system can be basically drawn as follows:

FIGURE 6

INFORMATION DERIVED CURVE

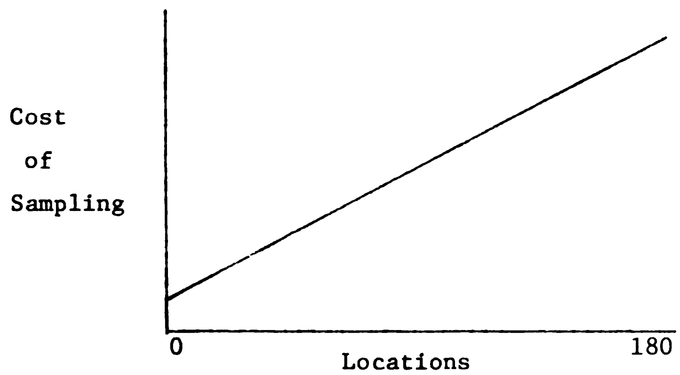


This figure simply indicates that the first few locations in any sample will make relatively large contributions to the amount of information derived from the audit tests.[1] As the number of locations included in the sample increases, the total amount of information derived may increase, but at a decreasing rate.

From data provided by past statistical records, the curve of the cost for the development and applying the audits at locations can be drawn somewhat as follows:

FIGURE 7

COST OF SAMPLING CURVE

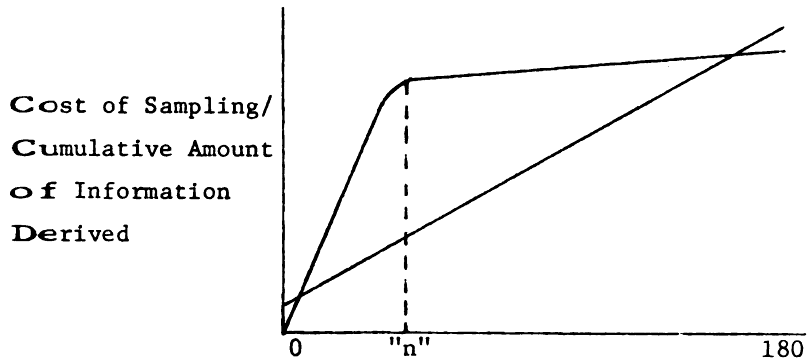


It was reasoned that this curve does not start at the axis intersection due to fixed costs in the development of the audit program. Cost generated by application at each location is considered relatively stable, increasing total costs at a constant rate as the number of locations in the sample is increased.

It was then hypothesized that the two curves combined would provide the following figure:

FIGURE 8

RATIO OF COST TO INFORMATION DERIVED



This figure indicates that as the number of locations in the sample is increased, costs increase at a constant rate. Information derived increases, but at a decreasing rate. To maximize the amount of information for the dollars spent, the size of the sample should be where the two curves are farthest apart, or at point "n."

The important conclusion reached from this line of reasoning is that costs are avoided as long as the audit program is applied at less than the population of locations. Further, the sample size can often be cut with very little loss of management information.

But an important question left unanswered at the conclusion of the discussion was: what is the actual shape of the "information derived curve"? Whereas the curve for actual costs of auditing is rather easily determined, determining the shape of the information derived curve is a more difficult task, one to which an approach must now be developed.

Mechanics of the Approach

To this point the discussion has been in general terms. The "information derived curve" has been discussed. It was stated that the curve is composed of "reportable type items" but the items were not precisely defined. Other key terms such as "local audit" and "centrally directed audit" were indirectly defined. The research accomplished was touched upon but, with the objective of only introducing the research topic, avoided excessive detail. Now, however, it is necessary to shift the mode of presentation -- to become involved with the nuts and bolts of the project.

The purpose of this section is to define key terms, provide a coding system to identify various phases of the research, and to specify the general criteria that are used in evaluating audit methods suggested by the research results.

Definitions

First, consider the definitions. A number of important terms specifically related to the research are used throughout the discussion. Some of the terms may be familiar, others will not be. Some of the terms relate specifically to the Air Force Audit Agency, others were developed and defined during the course of the research.

Some of these terms are again defined and explained during the discussion of the related phases of the research. Therefore to provide this discussion of terms at the outset invites a certain amount of redundancy. However, a basic acquaintance with these important terms at this point in the dissertation provides some insight into the research that follows:

The more important and frequently used terms are defined and/or explained below:

<u>Audit program</u>. An outline of steps to be followed or work to be done in accomplishing an audit.

<u>Audit survey</u>. A limited examination to determine the need for audit or the extent to which audit tests are to be applied.

<u>Auditor General Representative</u>. The title of the chief of an Auditor General Representative Office.

<u>Auditor General Representative Office (AGRO)</u>. An Auditor General office whose audit mission is primarily related to an Air Force organization as distinguished from an installation.

Auditor General Resident Office (AGRO). An Auditor General office whose audit mission is primarily related to an installation as distinguished from an Air Force organization.

Centrally directed audit. An audit scheduled by the Headquarters, Air Force Audit Agency. The appropriate audit programs are developed in response to requests from the Air Staff, higher levels of management, and internal sources. The programs are usually applied simultaneously at two or more locations throughout the Air Force. Auditors issue reports on their findings at each location in the same manner as for their locally scheduled audits. These reports, however, are usually forwarded to the Headquarters, Air Force Audit Agency, for summarization. The summary report of findings is provided to Major Commands, Air Staff, the Assistant Secretary of the Air Force for Financial Management, and through him to the Office of the Assistant Secretary of Defense, Comptroller.

Centrally directed audit program. An audit program prepared by the audit control point to accomplish a centrally directed audit.

Audit control point. An Auditor General element which is assigned responsibility for managing, programming, summarizing, analyzing, and reporting a centrally directed audit.

Segmented audit. A subject matter audit that is divided into parts. Each part is accomplished at a different sample of locations. The audit findings from each part are combined and summarized into a single report of audit. Such audits permit the expansion of audit coverage while controlling the total audit hours used.

Locally scheduled audit. Audit work scheduled and performed by an AGRO without direction from higher audit management authority. The Resident Auditor issues reports over his signature to the activity manager, the base commander, and the major air commanders.

Resident Auditor. The title of the chief of an Auditor General Resident Office.

Subject matter audit. An area, system, activity, function etc., on which a centrally directed audit has been completed.

Reportable type items. This term assumes different meanings depending upon the phase of research being discussed. In general, however, reportable type items are those items of information that are disclosed by a subject matter audit and that inform top levels of management of non compliance with management directives or of poor management practices.

For Phase 1 of the research, reportable type items are defined as items of "specific" information that are disclosed by a completed subject matter audit and that inform top levels of management of non compliance with management directives or poor management practices. The information is specific if it meets two criteria. First, each item of information must be separate and distinct from every other item of information. For example, for a subject matter audit of a clothing sales store one item may be that physical inventory counts made by auditors do not match balances recorded in perpetual inventory records maintained by managers. Second, the information must relate to inaccurate or undesirable actions that occur with a minimum frequency within the total subject matter audit. Specifically "minimum frequency" here relates to operating errors or poor management practices that are observed to occur in the field of audit observations at a rate of ten percent or more.

Using the example above to illustrate this second criterion, if for the completed subject matter audit ten percent or more of the comparisons between physical inventory counts made by auditors and balances recorded in management's records do not agree, then this item of information would be considered sufficiently material to interest top level managers and would be judged to be a reportable type item. This definition was developed through discussions with audit managers as one that will encompass most of the items of information reported to higher levels of management.

After analyzing the results of the phase 1 research, the definition of reportable type item is revised for phase 2 of the research. The revision pertains to the second of the two criteria discussed above -- that the information must relate to inaccurate or undesirable actions that occur with a minimum frequency within the total subject matter audit. Specifically, the revision is in the definition of "minimum frequency." For phase 1, the minimum frequency is ten percent of that which is examined in the subject matter audit when the subject matter audit is considered as a single unit. Using this definition it is possible that a very serious problem at a single location alone could cause the second criterion to be met. Yet, as previously reasoned, top level managers are not so much interested in isolated problems as they are in general problems that are in evidence at a number of locations. After discussion with audit managers, the "minimum frequency" was redefined in terms of the number of locations at which the problem was in evidence rather than as some error rate in the total records examined. The error rate in the records at each location remains important to judge the materiality of the condition at that location, but for this phase of the research, the materiality judgment is secondary to the determination of the general scope of the problem across locations.

Specifically, for the phase 2 research "minimum frequency" is examined at three different incidence levels. The operating error or poor management practice:

1. occurs at at least one of the locations in the universe of locations.
2. occurs at at least five percent of the locations in the universe of locations.
3. occurs at at least ten percent of the locations in the universe of locations.

Based on interviews with audit programmers and managers, the third alternative is considered the most representative of the type of problems of interest to top level managers. Information derived curves based on reportable type items defined by each of the alternatives were developed, however, to highlight the sensitivity of the curve to changes in definition.

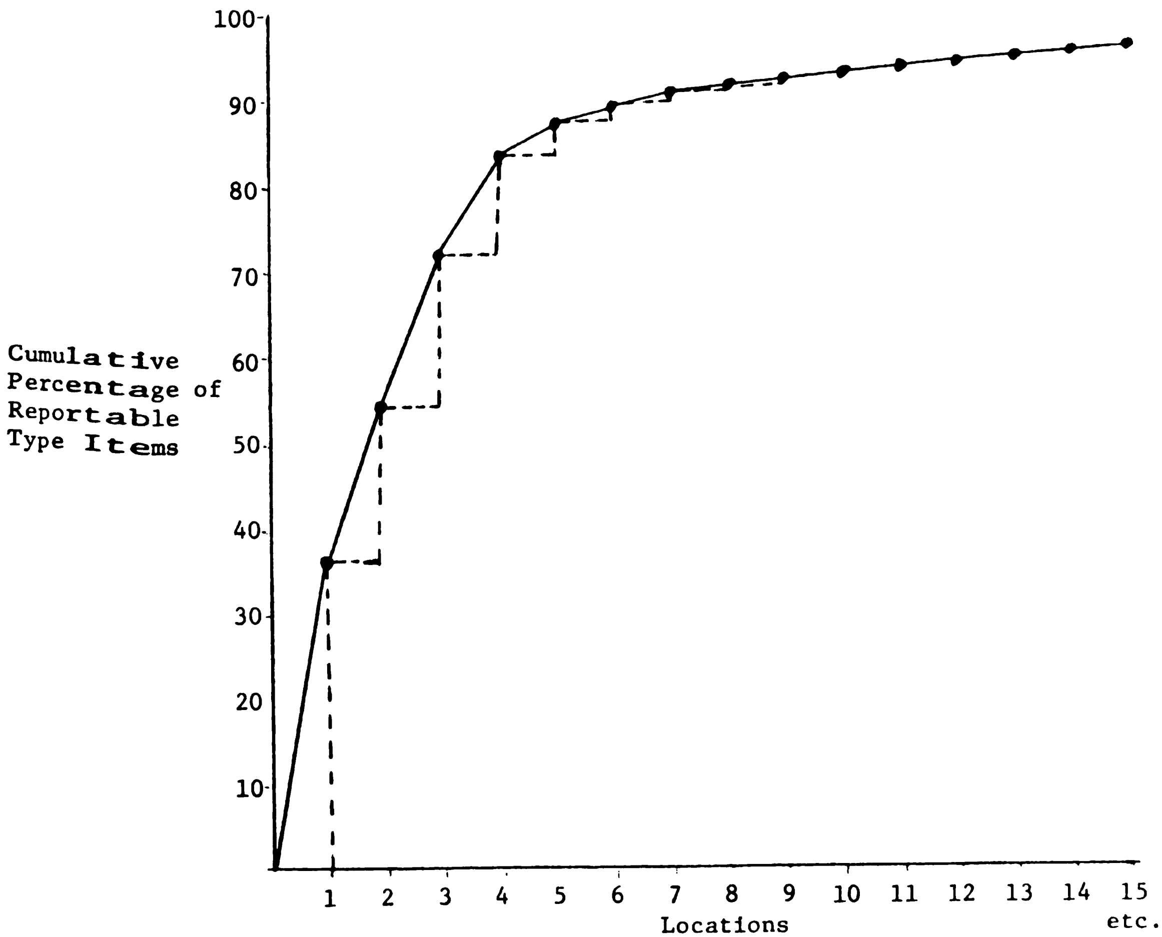
Finally, for phase 3 of the research the definition of reportable type items is that used for phase 2 assuming the third alternative for "minimum frequency" -- occurs at at least ten percent of the locations in the universe of locations.

Information derived curve. Initially it is best to think of the curve as the accumulation of new items of information (reportable type items) as provided by each additional location included in the audit. For example, assume that an audit in a specific activity (i.e. supply) was accomplished at 150 locations. Further assume that analysis of the total audit information from these locations yielded 100 different independent reportable type items, i.e. the first might be that unauthorized supplies were being ordered, the second that stock record cards were not accurately posted, etc. Now assume that one wishes to determine how much of this reported information could have been detected at a small sample of these 150 locations. The first location selected for the sample (however selected) would yield several of the original 100 kinds of items.

Assume for the sake of illustration that at the first location 36 of the 100 kinds of items are detected. Now turn to the hypothetically constructed information derived curve of Figure 9, page 56. Along the horizontal axis of the figure find the first location. Since 36 of a possible 100 kinds of items represents 36 percent of the total, proceed vertically until a position opposite the 36th cumulative percentage point is located and place a dot. This dot represents the first point on the information derived curve. Similarly, the second

FIGURE 9

CONSTRUCTION OF THE INFORMATION DERIVED CURVE



location in the sample would yield perhaps additional items of information not found at the first. Continuing the illustration, assume that the second location yields 18 kinds of items not detected at the first location. In cumulative terms, one will now have detected 54 or 54 percent of the original 100 total items. Again, along the horizontal axis of Figure 9 find the second location. Proceed vertically until a position opposite the 54th cumulative percentage point is located and place a dot. This dot represents the second point on the information derived curve. As additional locations are included in the sample, additional points on the information derived curve will be located. Finally, connect these points with a smooth solid line as shown in Figure 9 and the information derived curve is constructed.

Now look once again at this important curve, this time in a bit more detail. As shown in Figure 9, it is a solid line drawn on a graph with a vertical axis labeled "cumulative percentage of reportable type items" and a horizontal axis labeled "locations". The curve indicates the cumulative percentage of reportable type items in evidence up to any number of audit locations shown on the horizontal scale. Percentage rather than number of reportable type items is used on the vertical axis to permit comparison of the information derived curves for audits that vary in the absolute numbers of reportable type items.

It has been stated that the curve is a solid smooth line. The discerning reader may argue, however, that a correct plot of the data results in a series of discrete points, one above each numbered location rather than a continuous line. He might further argue that if the points are to be connected, the connection should be in a stair step fashion as illustrated by the dashed line in Figure 9. Reportable type items are accumulated at a location, not between locations. Mathematically speaking, these arguments are correct. However in this and subsequent chapters a number of information derived curves are compared simultaneously. To more easily visualize these comparisons, they are drawn as smooth continuous lines. While such construction takes some liberties with reality, the logic of the arguments that follow is not affected.

e curve. Since the primary curve that is referred to in this research is the information derived curve, it may be occasionally called "the curve" for short.

port of audit. A document which identifies the scope of the audit and conveys the auditor's findings and recommendations to the responsible manager or managers for appropriate action.

ernal audit. The independent, objective, and constructive review and appraisal of the effectiveness and efficiency with which managerial responsibilities in all areas (financial, operational, and support) are carried out at all levels of management.

p levels of management. Top levels of management may be defined differently depending upon the perspective of a given job level. To make the intended meaning here perfectly clear, top levels of management will refer to management above the base level. A synonym used is higher levels of management.

Phases of Research

The total research was completed over a three to four year time span with the bulk of the research completed in the most recent year. Accordingly the research is divided into three phases called appropriately enough: phase I, phase II, and phase III. Each phase of the research brings the actual shape of the information derived curve into sharper focus. An objective of discussing the research in three phases is to provide a complete rationale for the changes in audit methods both adopted following and as currently suggested by each phase. Each phase approaches the research in a different manner and uniquely contributes to the total knowledge.

Following an initial identification, a special coding system is used to identify subject matter audits analyzed in each of the three phases of the research. Specifically, the codes used are:

TABLE 1

SUBJECT MATTER AUDIT CODES

Phase	Subject Matter Audit Code
I	A_1, B_1, C_1
II	A_2, B_2, C_2, D_2
III	AJ BJ CJ DJ EJ FJ GJ
	HJ IJ
	AR BR CR DR ER FR GR
	HR IR

Different subject matter audits are used in the analysis at each phase. That is subject matter audit A of phase 1 is not the same audit as A of phase 2 nor of A of phase 3. Now focus specifically on the audit codes for phase I and II. Here, the numerical digit indicates the phase of the research -- a "1" for phase I and a "2" for phase II. Looking at the audit codes of phase III, notice that there are two sets of alphabetic codes of A-I. To the first set an alphabetic letter "J" is attached, to the second an "R". Both sets of alphabetic codes identify the same nine subject matter audits. The first set of nine is analyzed however using judgmental methods (coded "J") while the second set is analyzed using random selection techniques (coded "R").

Phases I and II are discussed in this chapter.

Phase III is presented in Chapter IV.

The Criteria

To evaluate the audit methods suggested by research results of each phase, criteria are used. Audit methods suggested by each phase are evaluated in terms of whether they are more effective and/or efficient than present methods.

Although the approximate meanings of the terms "effective" and "efficient" are intuitively obvious, the intended precise meaning must be made as clear as possible before proceeding with an evaluation of methods. Webster's New World Dictionary defines the word effective as "producing a definite or desired result."[2] The word efficient is defined as "producing a desired effect, product, etc. with a minimum of effort, expense, or waste."[3] Although the two words are listed as synonyms there are subtle differences that distinguish one from the other.

Argyris apparently ignored the distinction between the words, and indeed, seems to use the word "effective" in lieu of the word "efficient" in discussing organizational effectiveness:

> An organization increases in effectiveness as it contains: (a) increasing output with constant or decreasing inputs, or (b) constant outputs with decreasing inputs, and (c) is able to

> accomplish this in such a way that it can continue to do so.[4]

Chester I. Barnard, in his thought-provoking book on organization and management makes the statement that: "When a specific desired end is attained we shall say that the action is 'effective' . . . . Effectiveness relates to the accomplishment of the cooperative purpose."[5] He goes on to state that: "Efficiency relates to the satisfaction of individual motives . . . ."[6]

"Effectiveness" is used here in Barnard's sense. "Efficiency," however, is used not in the sense of Barnard, but rather in its more usual engineering sense: the optimum relationship between input and output. The more units of output that are obtained from a given input, the more efficient is the process or method. Units of output here will be the reportable type items of information previously mentioned. Units of input will be the locations included in the audit.

Additionally, the research results of phase III are judged using such additional criteria as cost, timeliness, quantity, and quality of information. Discussion of these criteria is touched upon in Chapter I. A more complete discussion is presented in Chapters V-VII that follow.

Research - Phase I

Arm chair reasoning such as that provided in the section titled The Sampling Rationale sooner or later must be confirmed by empirical research.

The Objective

Phase I of the research was accomplished to determine if the information derived curve is uniquely shaped as hypothesized.

The Reportable Type Item

As defined previously, reportable type items are in general those items of information that are disclosed by a subject matter audit and inform top levels of management of non compliance with managerial directives or of poor management practices.

For this phase of the research, an item of information must meet two specific criteria to be classified as a reportable type item. First, each item of information must be separate and distinct from every other item of information. Repeating an earlier example, one item may be that physical inventory counts made by auditors do not match balances recorded in perpetual inventory records maintained by managers. Second, the information must relate to inaccurate or undesirable actions that occur with a minimum frequency within the total subject matter audit. Specifically "minimum frequency" here relates to operating errors or poor management practices that are observed to occur in the field of audit observations at a rate of ten percent or more. Continuing the example, if for the completed subject matter audit ten percent or more of the comparisons between physical inventory counts made by auditors and balances recorded in management's records do not agree, then this item of information would be considered sufficiently material to interest top level managers and would be judged by this second criterion to be a reportable type item.

This definition was developed through discussions with audit managers as one that will encompass most of the items of information reported to top levels of management.

Selection of Subject Matter Audits

For the detailed analysis, audit managers were requested to provide the supporting data for three completed subject matter audits applied at 40 or more locations. Supporting data for the following completed subject matter audits were provided:

TABLE 2

SUBJECT MATTER AUDITS - PHASE I

(1) Audit Area	(2) Code	(3) Number of Audit Locations	(4) Number of "Items"
Accrued Military Pay	A_1	105	38
Commercial Transportation	B_1	177	37
Clothing Sales Store	C_1	162	41

Column 3 indicates the total number of locations at which the audit was applied. For each subject matter audit, column 4 indicates the total number of reportable type items.

Three subject matter audits applied at at least 40 locations each were selected because of the belief that this would be a sufficient number and size to indicate if the information derived curve rises rapidly enough to give promise of suggesting more economical means of abstracting audit information. Unless this were the case, additional and more detailed research would be useless.

Selection of Sample Locations

In searching for a bend in the information derived curve, it was arbitrarily decided to determine the cumulative percentage of reportable type items that can be detected at 10, 20, 30, and 60 locations. Accordingly, audit managers were requested to select judgmentally the first ten locations that they would have suggested for inclusion in the audit had the audit been limited to ten locations. Following that selection, audit managers were requested to select ten additional locations until all samples were identified.

At this point in the research, no attempt was made to identify the selection criteria used by audit managers. Where appropriate managers were requested to ignore as much as possible hindsight knowledge of results in making their selections. But again, no attempt was made to control specifically for such knowledge.

The Research

The detailed research consisted of first analyzing the supporting data for each subject matter audit to determine the total number of reportable type items. Next, data provided by the selected sample locations were examined to determine the cumulative number of reportable type items detected by each succeeding block of sample locations, i.e. 10, 20, 30 etc.

Results of the Research

Results of the research are recorded in the following table:

TABLE 3

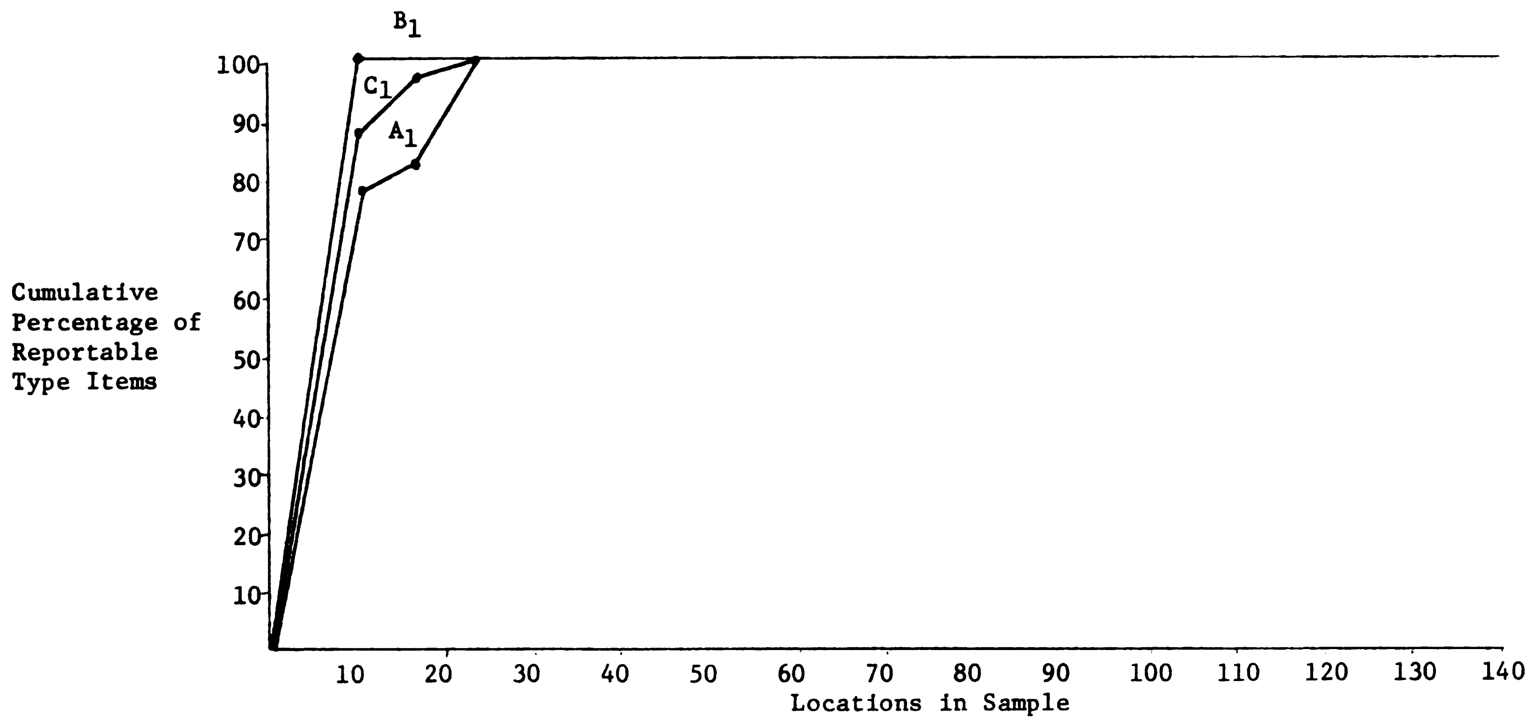
RESEARCH RESULTS - PHASE 1

Audit Code	Number of Locations Used	Number of Items Detected	Cumulative Percentage of Items
A_1	10	30	79
A_1	20	31	82
A_1	30	38	100
A_1	60	38	100
A_1	105	38	100
B_1	10	37	100
B_1	20	37	100
B_1	30	37	100
B_1	60	37	100
B_1	177	37	100
C_1	10	36	88
C_1	20	40	98
C_1	30	41	100
C_1	60	41	100
C_1	162	41	100

Plotting these results provides Figure 10, shown on page 69.

FIGURE 10

INFORMATION DERIVED CURVE - PHASE 1



An Evaluation of Results

Evaluating the results of this limited research provides some useful information for management, but suggests many additional lines of investigation, the results of which could result in even more effective and efficient operating methods.

On the positive side of the evaluation are listed the following:

1. The information derived curve for each subject matter audit is in general shaped as hypothesized in Figure 6, page 43.
2. Full detection of the reportable type items was achieved no later than at the thirtieth location selected from the population of locations -- at less than thirty percent of the universe of locations.
3. By continuing to audit at the population of locations, more information is being derived than is necessary to brief higher levels of management on general operating conditions.
4. Effectiveness could be maintained and efficiency improved if something less than the population of locations is included in each subject matter audit.

On the negative side of the evaluation the following comments are appropriate:

1. The research was not designed to give a clear indication of the rate at which reportable type items are detected as individual locations are added to the analysis. For example, 79 percent or more of the items for each subject matter audit are detected at 10 or less locations. But is this also true at five or six or seven locations? Such information is useful for:

    a. Determining the range of locations beyond which the incremental costs of audit tend to exceed the value of the incremental information.

    b. Assessing at each number of locations the risk of not detecting significant information of interest to managers.

    c. Suggesting other audit methods that are dependent upon the representativeness of the measured information at a small number of locations to that found at the universe of locations. These methods involve audit program development, field testing of audit programs, and segmented audits. They are elaborated upon in Chapters V-VII.

2. As a result of discussions with audit managers over the results of the phase I research, changes in the definition of reportable type items were suggested. A definition was needed that will permit not only the detection of management problems within a sample of locations, but also permit some assessment of the materiality of the problem across all locations. Based on contacts with top operating management, audit managers believed materiality must usually meet two criteria. First, the management problem must be revealed material at the specific location at which it is detected. Second, this problem must be in evidence at a number of individual locations. If the audit finding fails the first criterion, it is considered a minor problem of local managers. If it fails the second, it is a major problem for local managers but not a general problem to top level managers.

3. The rationale for using judgmental methods rather than random selection methods to choose the sample locations for the subject matter

audit is not provided.

Management Action

There is an old saying that the proof of the pudding is in the eating. Perhaps the most critical evaluation of research results -- the proof of the pudding -- is in the implementation of management methods suggested by the results. One major change in audit method was adopted by the Air Force Audit Agency following disclosure of the results from phase I. The number of locations to be selected for certain planned subject matter audits was reduced to 60, about one-third of those previously included.

Although this is a step toward more economical audit procedure, the data plotted in Figure 10 indicate that even more efficient procedures may be possible. By the tenth location a major portion of the reportable type items are detected. By the thirtieth location all reportable type items are in evidence. While the remaining thirty locations in a sixty location sample may provide a clearer picture of how extensive the management problem is across locations, one might ask the question -- is there a point or range at which the incremental value of the information added exceeds its incremental cost as additional locations are added to the sample? Is that point likely to be at less than 60 locations?

Additional Research Needed

To provide an answer to these questions it was obvious that additional research was necessary. For one thing, considerably more must be known about the generation of reportable type items as individual locations are added to the sample locations. Specifically, the shape of the information derived curve through the first ten locations is needed. Establishing a first point on the curve at the end of ten locations conceals this information. The additional research must also be designed in such a way that reportable type items are not only detected, but their materiality evaluated as well. If it can be shown that the management problems detected at small numbers of locations also meet an acceptable criteria for materiality, then the basic data is at hand to effectively compare the incremental value of adding an additional location to its incremental cost.

Research - Phase II

Phase I of the research provided some useful information. It indicated that the information derived curve is shaped basically as hypothesized. Although the curve was not determined with any great degree of precision, it was sufficiently definitive to audit managers to spark an important economical change in audit method. Considerably more information about the exact shape of the curve is needed, however, before it can be used with precision in determining economical sample sizes or for making other changes in audit methods. Some of this information is provided by phase II of the research.

The Objectives

The primary objective of phase II of the research is to determine the shape of the information derived curve over the span of the first ten locations of a judgmentally selected sample of locations. Secondary objectives are to analyze changes in the shape of the curve as the definition of reportable type items is varied and to make some assessment as to what percent of the information contained in the report of audit for each subject matter audit could have been provided to operating managers based on information derived from the sample of locations.

The Reportable Type Items

Reportable type items for phase II of the research are defined very similarly to reportable type items for phase I. Here also an item of information must meet the same two specific criteria to be classified as a reportable type item. First, each item of information must be separate and distinct from every other item of information. Second, the information must relate to inaccurate or undesirable actions that occur with a minimum frequency within the subject matter audit. But for phase II of the research there is a subtle change in the meaning of minimum frequency.

To make sure that the subtle change in the meaning of minimum frequency is made perfectly clear, recall its meaning for the phase I research. There minimum frequency related to operating errors or poor management practices that were observed to occur in the field of audit observations at a rate of ten percent or more. Using this definition it is possible that a very serious problem at a single location of the many locations included in the subject matter audit could cause the second criterion to be met.

It has been reasoned however that top level managers are not so much interested in problems that are isolated at one or two locations as they are in problems of general concern to a high percentage of the locations. The subtle change in the meaning of minimum frequency concerns the percentage of locations evidencing a problem. Such items as error rates in the records at a given location are important to judge the materiality of a condition at that location, but this materiality becomes secondary to the determination of the general scope of the problem across locations.

To provide adequate consideration for the scope of a management problem across locations, "minimum frequency" in the phase II research was considered at three different incidence levels. The operating error or poor management practice:

1. occurs at at least one of the locations in the universe of locations.
2. occurs at at least five percent of the locations in the universe of locations.
3. occurs at at least ten percent of the locations in the universe of locations.

Audit managers considered the third alternative to be most representative of the type of problems of interest to top level managers. Information derived curves based on reportable type items defined by each of the alternatives were developed, however, to highlight the sensitivity of the curve to changes in definition.

Selection of Subject Matter Audits

An important problem that arises in considering the selection of subject matter audits is how many should be selected? For the research in phase I, three were selected based on the rationale that three were sufficient to determine the feasibility of further research. As it turned out, audit managers revised their procedures based on the limited data. Although the adoption of improved audit procedures was not the primary objective of this initial research, such action is the motivating force underlying all of the research.

For phase II of the research a similar situation is faced. The primary objective of this phase is not to provide specific data that management will act upon, but such action is certainly the ultimate motivating force underlying the research.

The problem of determining "how many" was therefore approached by asking audit managers their opinion. Specifically, they were asked how many replications of the information derived curve would be required before they would be reasonably certain of its shape over a span of the first ten locations. Without knowing probable uses of the curve, the question was difficult to answer. However, considering the research results of phase I their professional opinion was that three or four additional curves would be sufficient. Since experience indicated that approximately four work days were required to construct each curve, this phase of the research was limited to the construction of four additional curves.

Audit managers were requested to provide the supporting data for four completed subject matter audits that were considered to be representative of the type of audits performed and that were applied at at least 40 locations. Supporting data for the following completed subject matter audits were provided:

TABLE 4

SUBJECT MATTER AUDITS -- PHASE II

(1) Audit Area	(2) Code	(3) Number of Audit Locations
Food Service	A_2	150
Aviation Fuels Division	B_2	152
Critical Item Control	C_2	143
Equipment Management Office	D_2	55

Selection of Sample Locations

Ten audit locations used in each of the subject matter audits must be selected. But how are they to be selected? In phase I of the research the locations were selected judgmentally by audit managers. Rationale for using a judgmental rather than a probability approach was not provided.

Perhaps at this time it is best to digress a bit and consider in general the various approaches to selecting audit locations. They appear to be two in number, a probability (statistical sampling) approach and a judgmental approach. The probability or statistical sampling approach is considered first.

There are two general methods by which a statistical sampling approach might be used to select locations for audit application. The first method would define the total number of locations as the universe, and depending upon the type of information desired from the sampling plan, compute a sample size, and provide for sample selection and summarization. This method would imply that the selection of the specific locations for audit application would be on some form of random basis.

This first method has several conceptual difficulties. First of all, the universe size (approximately 180 bases when dealing with Air Force locations) is too small to result in much savings, for most any sample size would approach universe size if statistically acceptable inferences concerning the population are made from the sample. A second difficulty with this approach is that the locations are not homogeneous in nature (this homogeneity problem is mentioned later), the primary restriction placed upon sample selection under a plan such as method one suggests. Such a plan would be difficult if not impossible to design in such a way as to provide economically statistically sound inferences.

A second general way to approach the problem is to use some specialized statistical techniques for universe stratification and sample selection. Typical of the techniques which could be used are stratification of the universe by some reasonable homogeneous characteristic, such as major command, and/or the use of cluster sampling techniques. This approach also presents difficulties. The most important difficulty and the one which precludes this approach arises from the large number of "unique" locations which do not fit in with a larger classification group. For example, within the Air Force, 10 out of the 18 major commands have 10 or fewer bases; 8 of these 10 have 3 or fewer bases. This implies that any statistically designed stratified sample would approach the size of the universe, just as was the case even if all the bases were considered a homogeneous group as in method one.

Of course, the ideal statistically designed sampling plan for audit application would define the universe not in terms of such locations as bases, but service (e.g., Air Force-wide), in terms of functions, processes or paper work. This would result in the computation of one sample size which would be spread or allocated to each base on a random basis. In this instance, the audit would be performed at all bases, but the amount of detailed testing performed would be quite minimal at given bases, and at a minimum in total. This alternative does not fit strictly within the objectives of this discussion, for it does not represent the application of audits of selected bases, rather it presents a method for decreasing the amount of detailed testing performed at all bases, where all bases will be audited.

Unfortunately, applying a single sample (where the definition of the universe is Air Force-wide and ignores base subdivisions) across all bases is fraught with difficulty. There are three basic accumptions which must underlie such an application, all dealing with the homogeneity of the Air Force-wide information system. The first assumption is that the system as designed (including all internal controls and information processing techniques) is substantially identical regardless of major command or base. This assumption is reasonable, in many cases. The second assumption is that actual internal controls and data handling are substantially identical at all bases; the third assumption is that the administrative and clerical effort and quality are substantially identical. Audits performed at various locations in the past have shown that this third assumption is not reasonable.

These three assumptions may occasionally be satisfied. However, even if this is true, another disadvantage exists. Information drawn under a single sampling plan for all bases would provide little information of use at the base level. The reason for this is that very few actual samples would be selected from any given base. Assume a sample size of 800 (which is certainly sufficient in most applications where a universe of infinite size is used). This would mean that there would be an average of approximately five samples drawn from each base. From a statistical viewpoint, summary information can be made Air Force-wide because of the assumption of homogeneity; unfortunately, common sense sometimes has to displace the finest of our statistical designs. In this case, it would be difficult to argue with any reasonable man that a sample of five from any base would provide information of value to the base commander. The auditor, even when performing an audit primarily for top management, has assumed a reporting responsibility to the local commander, and such an approach is untenable.

As far as the selection of certain bases for audit application on a statistical basis is concerned, it does not appear to be a wise course of action. The primary reasons for this are the nonhomogeneity of the universe, the minimal savings promised because of a high sample size/ universe ratio, and the conceptual argument that except for special studies, statistical inferences dealing with operations are not needed at higher than base level.

Obviously, if statistical methods are not used in selecting locations at which the audit will be applied, then a judgmental method will be used. Use of this method requires both a thorough understanding of the method and the difference between it and the statistical method. First, consider the difference in methods.

Any sampling plan can be thought of as consisting of three discrete processes: determination of sample size, a selection of the sample, and summarization of sample results. When a statistically designed sample is used, the selection and summary processes are also statistically performed. When a sample size is determined judgmentally, summarization may include quantitative statements (e.g., in our sample of 800, we found a 10% error rate), but cannot include probabilistic statements about the results (e.g., the error rate of the total population is estimated between 8 and 12%, and we can make this statement with 95% confidence).

With regard to using a judgmental approach to determining sample size and selecting the sample, there is a central guiding criterion. A sample size should be determined and the specific locations chosen in such a way as to provide information to top management which is representative of the total information system under audit.

For illustrative purposes, assume that the auditor wishes to select a number of Air Force bases at which to review a particular system in operation. Then his selection of the particular locations or bases would depend upon answers to such questions as:

1. Who requested that this audit be performed?
2. Why did that request originate?
3. What specific problem or information need prompted the request? (to what use will the report be put)?
4. Is the information need peculiar to a given portion of the total information system of the Air Force?
5. Are matters dealing with system design, policies, and operations within the system sufficiently uniform so as to be able to make judgments about the total system on a less than total system examination?
6. How many bases are likely candidates for the

application of the audit program?

7. What are the characteristics of the bases which bear upon their role in this information system (size, command, etc.)?

8. How many bases would have to be examined in order to provide information as to the general strengths and weaknesses of the system under study?

9. At which bases will the system be the most representative of the Air Force-wide system?

10. In what form should the recommendations be made?

Top management must receive results of audit oriented to a total system; it follows that the sample should be selected in such a manner that the bases used for audit application will have operations which are deemed to be representative of the total system. Answering such questions as listed above is not easy, for specific guidelines are hard to state. Some scheme for classifying bases by the nature of their participation in the information system must be used. Some of the classification parameters could be the size of the system at the base, the volume of paperwork handled, the techniques for information processing, whether the base is domestic or foreign, the major command to which the base is assigned, and experience of the auditor making the audit. All of the parameters are the type of characteristics which lead to formal stratification when statistical sampling is used. In a similar way, they should influence the selection of the bases for audit application on a judgmental basis.

For the samples for the present four subject matter audits, audit managers were requested to select judgmentally for each audit the ten locations that they would have suggested for inclusion in the audit had the audit been limited to ten locations. The primary objective for the selection of the locations was to detect by sample the management problems that existed in the universe of locations.

As in phase I of the research, no attempt was made at this point in the research to identify the selection criteria used by audit managers. To provide representative rather than biased results, audit managers in making their selections were requested to ignore as much as possible hindsight knowledge of audit findings at specific locations. But again, no attempt was made to control specifically for such knowledge.

The Research

The four selected subject matter audits had originally been applied at 500 locations. Information from these 500 individual audits was analyzed to determine the number of reportable type items. The shape of the information derived curve over the span of the first ten locations of a judgmentally selected sample of locations was then determined. That is, points were plotted on a graph in a manner described in considerable detail earlier in the chapter. The points represented the cumulative percentage of reportable type items detected after the first, second, third, and so on up thru the tenth location.

The shape of the information derived curve was determined three times for each subject matter audit -- once for each of the three different definitions given to the reportable type items. One curve was plotted when the definition involved the detection of all audit findings from the universe of audit locations of the completed subject matter audit. A second curve was plotted when the definition involved the detection of those audit findings that were in evidence of five percent or more of the universe of audit locations of the subject matter audit. The third curve was similar to the second except that it involved detection of those audit findings that were in evidence at ten percent or more of the universe of locations.

Since the end product of the audit is information, an analysis was made of the reportable type items composing the third curve to determine the percentage of all information in the report of audit for the subject matter audit that was also materially present in the sample of locations. Stated another way, an analysis was made to determine what percent of the reported information could be provided to operating managers based on information derived from the sample of locations. The percentage was determined at the end of the first five locations and at the end of the tenth location for each sample of locations.

To make this analysis in a quantifiable manner, some objective criteria were needed to judge the materiality of the reportable type items found in each sample. Note that the materiality of an item that did appear in the report of audit was not questioned. An item considered material by one person may be considered as immaterial by another. Or the same person may be inconsistent in his assessment of materiality depending upon the time and the circumstances. The materiality of an item may depend on its size, its nature, or a combination of both.[7]

Audit managers generally agreed that materiality of the reportable type items found in the sample of locations could be judged based primarily on two factors: frequency and magnitude. Frequency refers to the number of locations in the sample at which a particular error occurred.

Magnitude refers to the extent of the error at any one location. Data characteristics of frequency and magnitude influence the value of derived information, both to system managers and audit managers.

To illustrate the importance of these characteristics to system managers, assume that each of ten bases has 1,000 items of equipment in use. An audit discloses that one item at each base is not properly authorized. Base frequency for this error is 100 percent (10 of 10 bases indicate the error), but the magnitude of occurrence is less than one percent (10 of 10,000). Considering frequency alone, the condition seems significant. When the characteristic of magnitude is added, assessment of the situation changes. To be of value to system managers, to be considered material, a problem area must exhibit a proper balance of frequency and magnitude.

Of course it is not practical to state what that balance should be in all cases. The experienced auditor knows that there are often areas within an operating activity that are of more concern to top level managers than are other areas. For these sensitive areas, the degree of frequency and magnitude of management problems required to make them of interest to top level managers may be far less than the degree required in other less sensitive areas.

Therefore hard and fast rules to test materiality are usually not possible.

However, over the years audit managers do develop general guidelines -- rules of thumb to determine the materiality of audit findings. From discussions with audit managers at the time of this research, the following general guide to judging the materiality of reportable type items found in the sample of locations was suggested:

TABLE 5

FACTOR TESTS FOR MATERIALITY

Factor	Five Location Sample	Ten Location Sample
Frequency	Two or more locations	Three or more locations
Magnitude	Ten percent, or if less than ten percent, equal to the reported percentage.	Ten percent, or if less than ten percent, equal to the reported percentage.

But to ensure comparability between the information contained in the report of audit and that provided by the sample of locations, two additional actions were taken. First, the frequency of occurrence of all reported information was reviewed. Those reported management problems that occurred at less than ten percent of the universe of locations were dropped from further consideration. Such problems would not qualify as reportable type items for the information derived curve of primary interest. And second, if the data provided by the sample of locations failed the test for materiality specified in Table 5, one additional test was given. The frequency and magnitude of the data in the sample was compared with the frequency and magnitude of the reported information in the universe. If both the frequency and magnitude of the data in the sample was equal to or greater than that from the universe, the sample information was judged to be reportable. This latter modification to the materiality criterion was made so that management problems of a sensitive nature that perhaps need not occur as often as other problems to be of concern to top management are given equal consideration both in the universe of locations and in the sample of locations.

Results of the Research

The primary objective of phase II of the research was to determine the shape of the information derived curve over the span of the first ten locations of a judgmentally selected sample of locations. This objective is met, as elaborated upon earlier, using three separate definitions of "minimum frequency" in determining reportable type items.

These are:

Definition 1: The operating error or poor management practice occurs at at least one of the locations in the universe of locations.

Definition 2: The operating error or poor management practice occurs at at least five percent of the locations in the universe of locations.

Definition 3: The operating error or poor management practice occurs at at least ten percent of the locations.

The number of reportable type items applicable to each subject matter audit varied with the above definitions as shown in Table 6, page 94. For example, audit A_2 had 61 reportable type items when definition 1 was applied. Using definition 2 the number was reduced to 54, and for definition 3, it was further reduced to 40. This reduction in number is as expected since each succeeding definition pertains to more exclusive information. This general pattern of reduction can be observed for each of the three remaining subject matter audits as well.

Consider now the reportable type items determined by using definition 1. The cumulative number of these

TABLE 6

REPORTABLE TYPE ITEMS - PHASE II

Audit Code	Number of Reportable Type Items		
	Definition 1	Definition 2	Definition 3
A_2	61	54	40
B_2	150	70	36
C_2	116	96	75
D_2	202	176	135

reportable type items detected by the judgmental sample of ten locations for each of the subject matter audits is recorded in Table 7, page 96. To illustrate the information contained in the table, the recorded data for audit code A_2 is reviewed. At the first location 23 of the possible 61 reportable type items are detected. At the second location three additional items not detected at the first location are found for a cumulative total of 26. The other locations contribute information similarly thru the tenth location at which point 49 of the total 61 reportable type items are in evidence.

Table 7 provides absolute numbers of reportable type items. Since the total of reportable type items for each subject matter audit differs, here ranging from 61 to 202, it may be difficult for the observer to determine the rate at which new information is being accumulated as locations are added to the sample. It may be easier to visualize this rate if the data for each subject matter audit is converted into a common measuring device. This is done in Table 8.

In Table 8 the absolute numbers of Table 7 have been converted to common percentages. Again using audit code A_2 as an illustration, at the first location 38 percent of the total reportable type items are detected. At

TABLE 7

CUMULATIVE NUMBER OF REPORTABLE TYPE ITEMS FOUND -- DEFINITION 1

Audit Code	Total Number of Items (Table 6)	Locations									
		1	2	3	4	5	6	7	8	9	10
A_2	61	23	26	37	43	46	46	46	47	48	49
B_2	150	24	32	38	42	48	51	54	62	65	72
C_2	116	38	53	61	75	86	88	90	94	95	100
D_2	202	46	99	143	149	160	162	166	168	168	172

TABLE 8

CUMULATIVE PERCENTAGE OF REPORTABLE TYPE ITEMS FOUND -- DEFINITION 1

	Locations									
Audit Code	1	2	3	4	5	6	7	8	9	10
A_2	38	42	61	70	76	76	76	78	79	81
B_2	16	21	25	28	32	34	36	41	43	48
C_2	33	46	53	65	74	76	78	81	82	86
D_2	23	49	71	74	79	80	82	83	83	85

the second location an additional 4 percent not found at the first location are detected for a total cumulative percentage of 42. The other locations contribute information similarly thru the tenth location at which point 81 percent of the total reportable type items are in evidence.

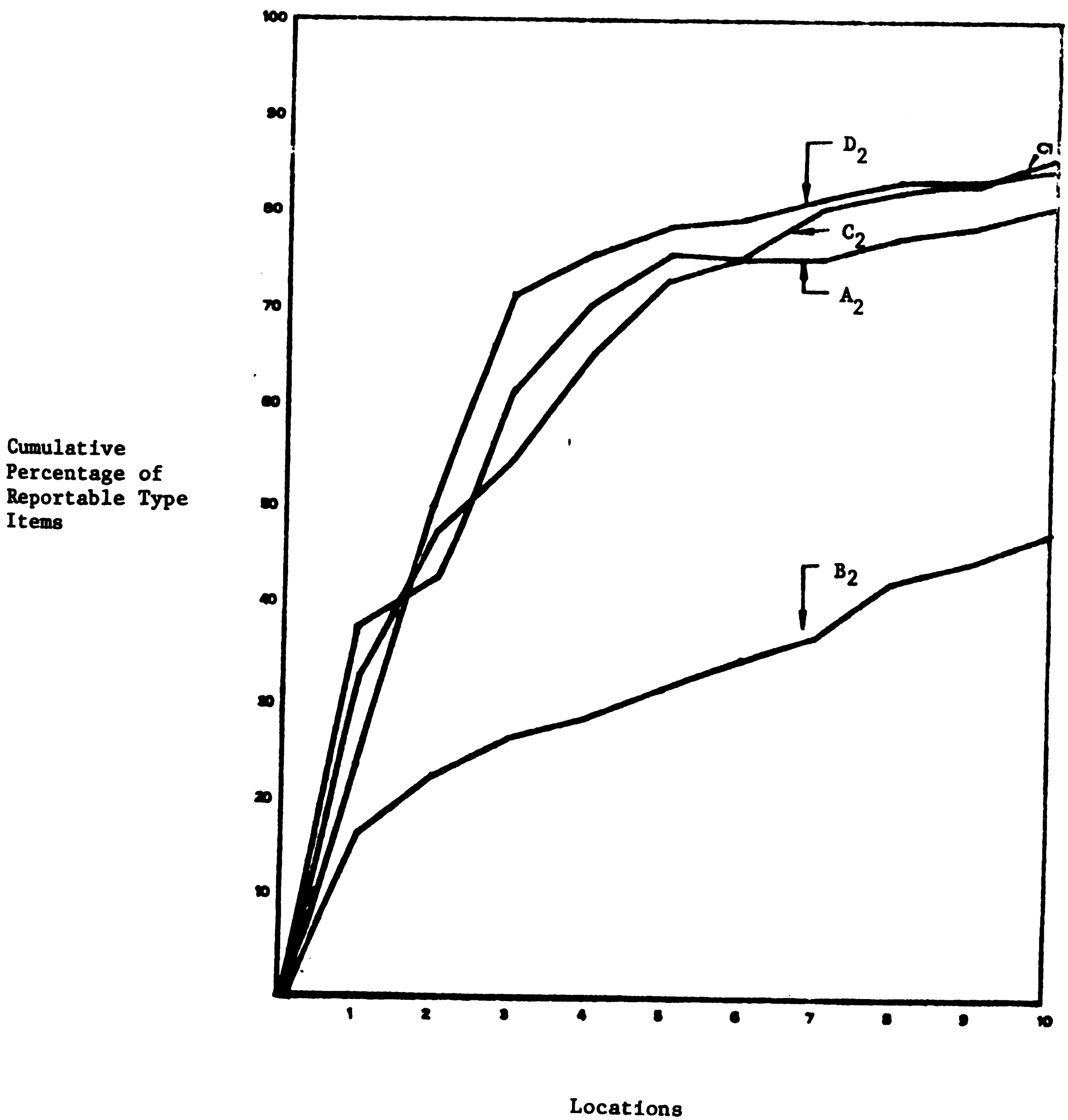
As a final aid in visualizing this data, Figure 11, page 99 is prepared. This figure uses the data from Table 8 to illustrate graphically the information derived curves -- the objective of this analysis. Note particularly that the curve for audit B_2 radically departs from the curves for A_2, C_2, and D_2 which are in turn, very similar. This departure in shape will be of particular interest in the subsequent evaluation of this data.

Consider now the reportable type items determined by using definition 2. The cumulative number of these reportable type items detected by the judgmental sample of ten locations for each of the subject matter audits is recorded in Table 9, page 102. Table 10, page 103 provides this same data in cumulative percentage form. Figure 12, page 104, graphically illustrates the information derived curves.

Finally, consider the reportable type items determined by using definition 3. The cumulative number of these reportable type items detected by the judgmental

FIGURE 11

INFORMATION DERIVED CURVES
DEFINITION 1



sample of ten locations for each of the subject matter audits is recorded in Table 11, page 105. Again, Table 12, page 106 provides this same data in cumulative percentage form. Figure 13, page 107, graphically illustrates the information derived curves.

As stated earlier, the analysis of data using three definitions to identify reportable type items was made to demonstrate the effect of a definition change on the shape of the resulting information derived curves. The curve developed using the third definition -- the operating error or poor management practice occurs at at least ten percent of the locations -- will receive primary attention in the analysis to follow. Recall that this definition was suggested by audit managers as being the most meaningful for identifying management problems of probable interest to top level management.

A second area of research concerns determining the percentage of information contained in the report of audit for each subject matter audit that could have been provided to operating managers based on information derived from the sample of locations. Using the criteria previously discussed, the percentages are as shown in Table 14, page 101.

TABLE 14

PERCENTAGE OF REPORTED INFORMATION
AVAILABLE FROM SAMPLES

Audit Code	Sample Size: Five Locations	Sample Size: Ten Locations
A_2	63	73
B_2	68	74
C_2	73	73
D_2	70	70
Average:	69	73

TABLE 9

CUMULATIVE NUMBER OF REPORTABLE TYPE ITEMS FOUND -- DEFINITION 2

Audit Code	Total Number of Items (Table 6)	Locations									
		1	2	3	4	5	6	7	8	9	10
A_2	54	23	25	38	42	45	45	45	46	46	48
B_2	70	16	23	28	29	32	34	36	42	43	58
C_2	96	34	45	56	68	78	80	82	84	86	88
D_2	176	49	97	137	143	151	153	158	162	162	165

TABLE 10

CUMULATIVE PERCENTAGE OF REPORTABLE TYPE ITEMS FOUND -- DEFINITION 2

Audit Code	Locations									
	1	2	3	4	5	6	7	8	9	10
A_2	42	46	70	77	83	83	83	85	85	89
B_2	23	33	40	42	46	49	52	60	63	83
C_2	35	47	58	71	81	83	85	88	90	92
D_2	28	55	78	81	86	87	90	92	92	94

FIGURE 12

INFORMATION DERIVED CURVES
DEFINITION 2

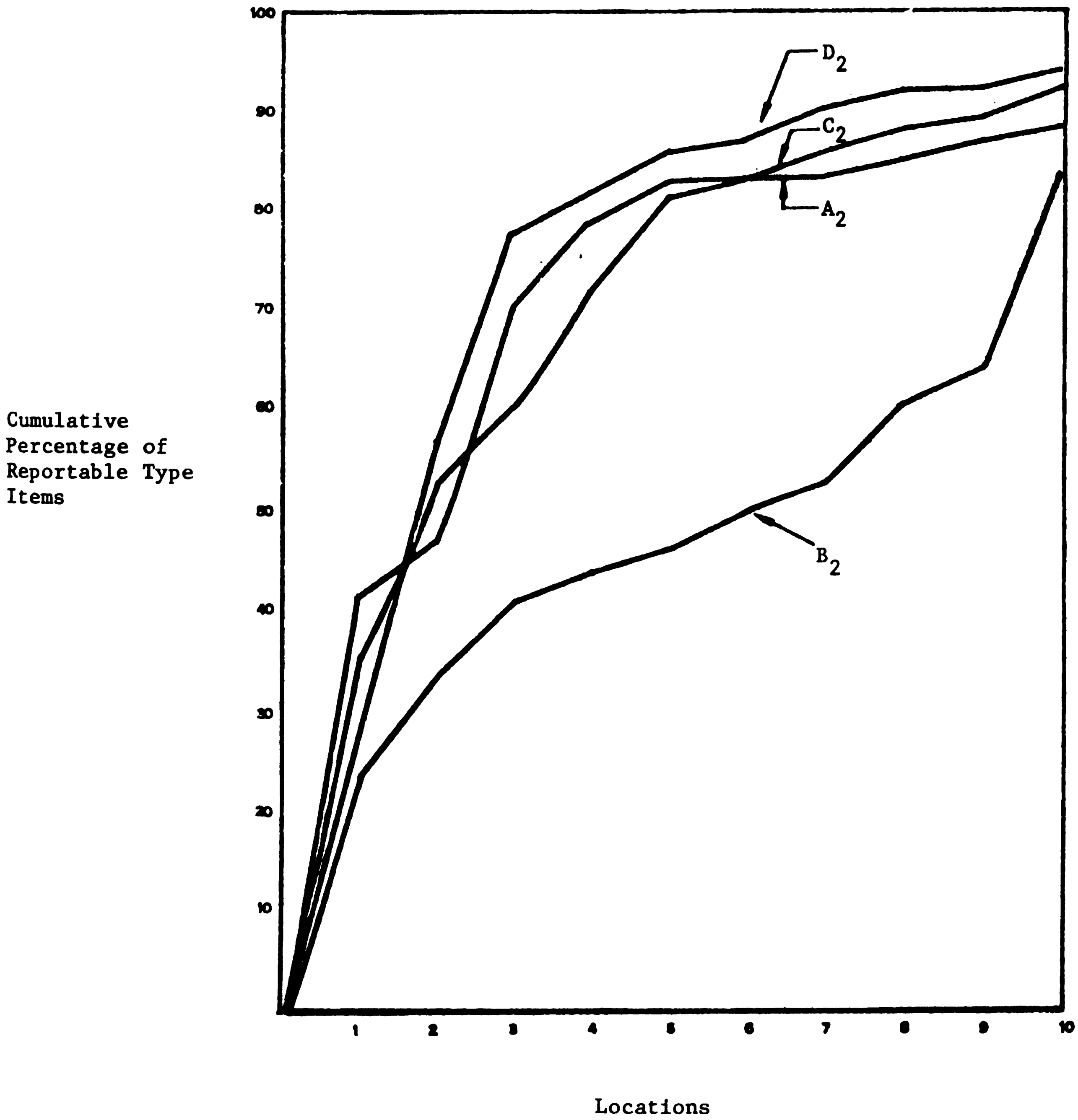


TABLE 11

CUMULATIVE NUMBER OF REPORTABLE TYPE ITEMS FOUND -- DEFINITION 3

Audit Code	Total Number of Items (Table 6)	Locations									
		1	2	3	4	5	6	7	8	9	10
A_2	40	16	25	32	35	37	37	37	38	38	38
B_2	36	12	18	23	28	28	29	30	31	32	32
C_2	75	28	35	45	56	63	66	68	69	71	72
D_2	135	41	81	111	117	126	127	128	130	132	134

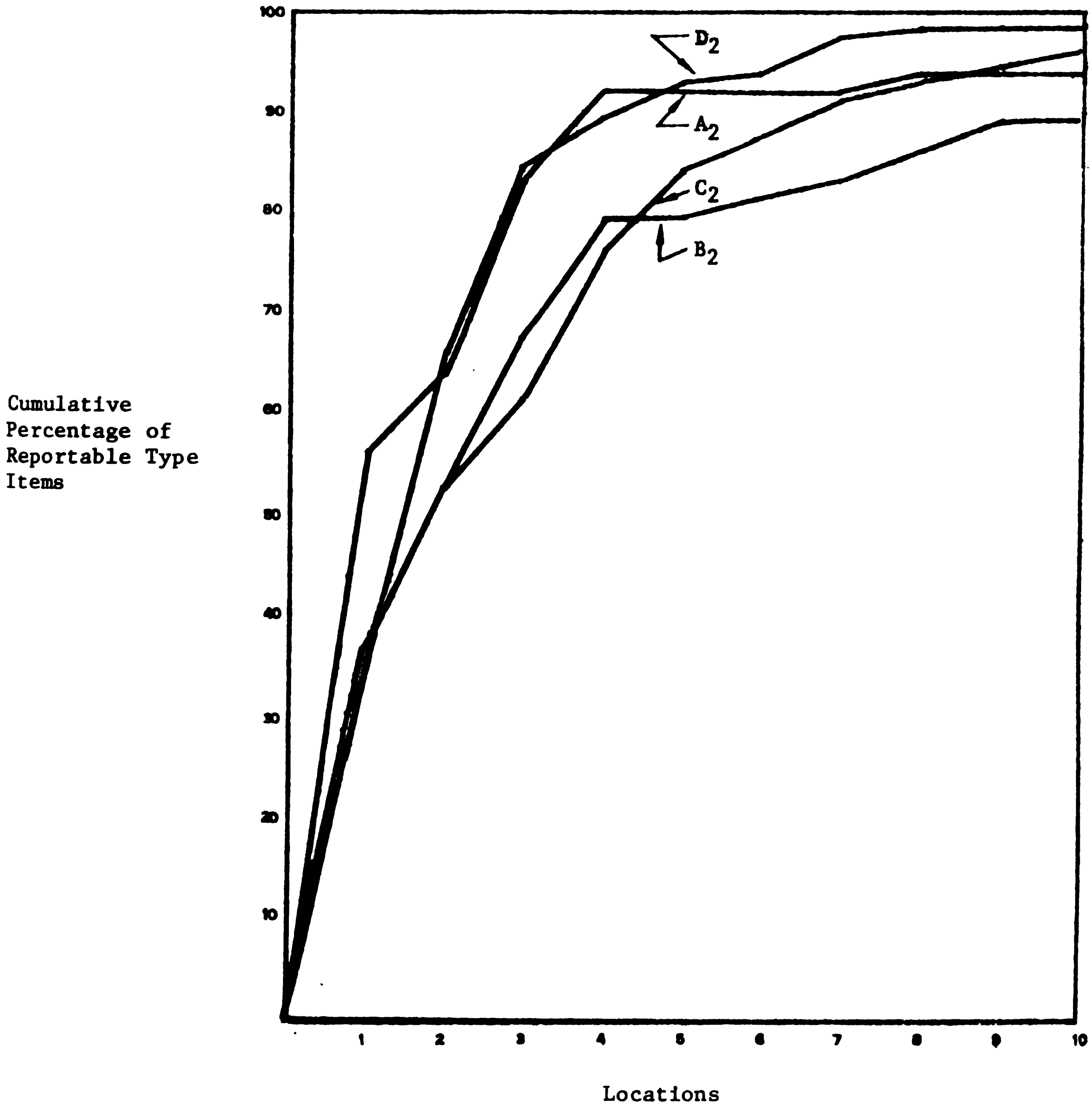
TABLE 12

CUMULATIVE PERCENTAGE OF REPORTABLE TYPE ITEMS FOUND -- DEFINITION 3

	Locations									
Audit Code	1	2	3	4	5	6	7	8	9	10
A_2	41	63	80	88	92	92	92	94	94	94
B_2	33	50	64	79	79	81	82	84	89	89
C_2	37	47	60	75	84	88	91	92	95	96
D_2	30	60	82	89	93	94	95	96	98	99

FIGURE 13

INFORMATION DERIVED CURVES
DEFINITION 3



An Evaluation of Results

One of the most important stages of a research project is evaluation of results. There the key question of what does it all mean is answered. The following evaluation discloses that when, as audit managers suggest, reportable type items are defined as operating errors or poor management practices that occur at at least ten percent of the locations in the universe of locations, then the resulting information derived curve for each subject matter audit is similarly shaped. These information derived curves suggest important new objective methods for managing the development of audit programs, for handling the field test of new audit programs, and for accomplishing what are here called "segmented audits." Finally, the evaluation discloses that a significant portion of the information that is reported to top level managers from the completed subject matter audit applied at the universe of locations could also be reported if the audit were restricted to a sample as small as ten locations. To develop these disclosures the detail of the evaluation is now considered.

First, consider the information derived curves that result from detecting reportable type items as defined by definition 1 -- the operating error or poor management practice occurs at at least one of the locations in the universe of locations. Data for these curves and the graphed curves are contained in Tables 7 and 8, and in Figure 11.

Note particularly the divergence of the data for audit B_2 from that of audits A_2, C_2, and D_2. Table 8 indicates, for example, that by the fifth location in the sample 32 percent of the total reportable type items in the universe are located. By contrast, the cumulative percentages of reportable type items detected by the fifth sample location for audits A_2, C_2, and D_2 are 76 percent, 74 percent, and 79 percent respectively. By the tenth location 48 percent of the reportable type items for audit B_2 are detected while for audits A_2, C_2, and D_2 these percentages are 81, 86, and 85 respectively. This divergence in results may be observed visually in Figure 11.

One can conclude that by using definition 1, the information derived curves for audits A_2, C_2, and D_2 are very similar. They all rise very rapidly over the first few locations included in the sample. The curves tend to level off between the fourth and sixth locations. Additional reportable type items are detected, but at a much reduced rate. Specifically, the average detection of reportable type items by the fifth location is just over

76 percent with a maximum difference in ordinates between any one curve and the average curve of less than 3 percent. Doubling the sample size to ten locations results in an average detection of reportable type items of 84 percent, a gain of only 8 percent for a 100 percent increase in effort. The difference in ordinates between curves remains at a very low 3 percent. The least percentage of information detected using any one of these audits by the fifth location is 74 percent, by the tenth location it is 81 percent.

But precluding any projected use of this information is the seemingly uncharacteristic results of audit B_2. What causes such results? Can the results be controlled?

In seeking an answer to these questions recall first the primary objective of the subject matter audit. It is to inform top level management of non compliance with management directives or of poor management practices at the operating locations. Audit managers have reasoned that generally to be of interest to top level management the problem should be in evidence at a number of operating locations -- ten percent of such locations being suggested as a rule of thumb guide.

Contrast this general criterion for evaluating significance of audit findings to the criterion for determining a reportable type item for the above information derived curves. This latter criterion is that the management problem occurs at only one or more of the operating locations. Perhaps the reportable type items for audit B_2 that are <u>not</u> detected by the sample of locations are primarily of a type that would likely be of little interest to top level management. If so, perhaps elimination of such reportable type items would cause the information derived curve to take on the characteristics described for the curves pertaining to audits A_2, C_2, and D_2. As will be pointed out, this is precisely the case.

Table 13, page 112 presents for each subject matter audit a detailed analysis of the percentage of reportable type items that occurred at 4 percent or less locations. To illustrate the use of Table 13, consider the information recorded for audit A_2. The first line for audit A_2 indicates that 2 percent of all reportable type items occurred at only 1 percent of the universe of locations included in the subject matter audit. Line two for audit A_2 indicates that there were no reportable type items that occurred at only 2 percent of the universe of locations. The total for audit A_2 indicates that 12 percent of all reportable type items occurred at 4 percent or less locations. Data recorded for the other subject matter audits are interpreted

TABLE 13

REPORTABLE TYPE ITEMS AT 4 PERCENT OR LESS LOCATIONS

Audit	Frequency at All Locations (Percent)	Percentage of These Items to All Items
A_2	1	2
A_2	2	0
A_2	3	5
A_2	4	5
Total		12
B_2	1	21
B_2	2	13
B_2	3	12
B_2	4	7
Total		53
C_2	1	3
C_2	2	2
C_2	3	5
C_2	4	7
Total		17
D_2	1	0
D_2	2	4
D_2	3	0
D_2	4	9
Total		13

in the same fashion.

Now look carefully at the data in Table 13 for audit B_2. Note that more than half of all reportable type items (53 percent) are applicable to 4 percent or less of the universe of locations. By contrast, only 12 percent of the items for audit A_2, 17 percent of the items for audit C_2 and 13 percent for audit D_2 are of this category. To further illustrate the isolated nature of the audit findings of B_2, one of each five reportable type items (21 percent) used in the construction of the information derived curve occurred at only one or two of the 152 locations included in the audit. One can conclude that most of the information generated by audit B_2 would not have been of interest to top level managers.

Eliminating from the data reportable type items that occur at four percent or less of the locations in the universe of locations results in definition 2 for reportable type items -- the operating error or poor management practice occurs at at least five percent of the locations in the universe of locations. Data for the information derived curves using this definition for reportable type items are recorded in Table 9, page 102, and in Table 10, page 103. The resulting information derived curves are shown in Figure 12, page 104. By constrasting the information recorded in Table 8 and Figure 11 with that recorded in Table 10 and Figure 12, two important facts are observed:

1. The information derived curves using definition 2 for reportable type items have shifted upward from the curves using definition 1 for the items. For example, contrasting the cumulative percentages at the tenth location in Table 8 with that of Table 10 the following is observed:

TABLE 15

COMPARISON OF DATA DEFINITION 1 vs 2

Audit	Location 10 Definition 1 Cumulative Percentage	Definition 2 Cumulative Percentage
A_2	81	89
B_2	48	83
C_2	86	92
D_2	85	94

2. The information derived curve for audit B_2 is beginning to approximate more nearly the curve for the other three audits.

But of more important interest to the audit manager is to detect those management problems that occur at ten percent or more of the universe of locations. In the above analysis when reportable type items found at four percent or less locations were eliminated from consideration, the information derived curve for audit B_2 began to approximate more nearly the shape of the curves for audits A_2, C_2, and D_2. One might hope that by concentrating upon the specific type of information of interest to top level managers, the information derived curves would become even more similar in shape. As indicated in the discussion that follows, this is the result.

Table 16, page 116, presents for each subject matter audit a detailed analysis of the percentage of reportable type items that occurred at 9 percent or less locations. The data in the table are interpreted in the same manner as that found in Table 13 previously described.

Now look carefully at the data in Table 16 for audit B_2. Note that 75 percent of all reportable type items are applicable to 9 percent or less of the universe of locations. By contrast, only 35 percent of the items for audit A_2, 34 percent of the items for audit C_2, and 33 percent for audit D_2 are of this category. One can again conclude that most of the information generated by audit B_2 would not have been of interest to top level managers.

Eliminating from the data reportable type items that occur at nine percent or less of the locations in the universe of locations results in definition 3 for reportable type items -- the operating error or poor management practice occurs at at least ten percent of the locations in the

TABLE 16

REPORTABLE TYPE ITEMS AT 9 PERCENT
OR LESS LOCATIONS

Audit	Frequency at All Locations (Percent)	Percentage of These Items to All Items
A_2	1	2
A_2	2	0
A_2	3	5
A_2	4	5
A_2	5	7
A_2	6	3
A_2	7	0
A_2	8	8
A_2	9	5
		35
B_2	1	21
B_2	2	13
B_2	3	12
B_2	4	7
B_2	5	9
B_2	6	2
B_2	7	6
B_2	8	0
B_2	9	5
		75

TABLE 16--Continued

Audit	Frequency at All Locations (Percent)	Percentage of These Items to All Items
C_2	1	3
C_2	2	2
C_2	3	5
C_2	4	7
C_2	5	4
C_2	6	7
C_2	7	0
C_2	8	4
C_2	9	2
		34
D_2	1	0
D_2	2	4
D_2	3	0
D_2	4	9
D_2	5	6
D_2	6	0
D_2	7	8
D_2	8	0
D_2	9	6
		33

universe of locations. Data for the information derived curve using this definition for reportable type items is recorded in Table 11, page 105, and in Table 12, page 106. The resulting information derived curves are shown in Figure 13, page 107. By reviewing these data and by contrasting them with the data discussed earlier for the previous two definitions of reportable type items the following observations are made:

1. The information derived curve for audit B_2 is now similarly shaped as the curves for audits A_2, C_2, and D_2.
2. The curves using definition 3 for reportable type items have shifted upward from the curves using definition 2 for the items. For example, contrasting the cumulative percentage at the tenth location in Table 10 with that of Table 12 the following is found:

TABLE 17

COMPARISON OF DATA DEFINITION 2 vs 3

	Location 10	
Audit	Definition 2 Cumulative Percentage	Definition 3 Cumulative Percentage
A_2	89	94
B_2	83	89
C_2	92	96
D_2	94	99

3. All the curves rise very rapidly over the first few locations included in the sample. The curves tend to level off between the fourth and fifth locations. Additional reportable type items are detected, but at a much reduced rate. Specifically, the average detection of reportable type items by the fifth location is 87 percent with the maximum difference in ordinates between any one curve and the average curve of about 8 percent. Doubling the sample size to ten locations results in an average detection of reportable type items of 95 percent, a gain of only 8 percent for a 100 percent increase in effort. The difference in ordinates between curves is no more than 6 percent. The least percentage of information detected using any one of these audits by the fifth location is 79 percent, by the tenth location it is 89 percent.

Finally, perhaps the nature of the items of information not detected by the sample of ten locations should be analyzed briefly. Specifically, what were the frequencies of occurrence for these "items" in the all-location audit? The analysis disclosed that only six items had an all base frequency rate of 14 percent or more. Four of the items had a frequency rate of 14 percent, one item had a frequency rate of 20 percent, and the sixth item had a frequency rate of 24 percent.

Now one may return directly to the questions asked after viewing the seemingly uncharacteristic shape of the information derived curve for audit B_2 shown in Figure 11. That is, what causes such results? Can the results be controlled?

The cause is due to the attempt to locate <u>all</u> isolated management problems in a large universe of locations by using a very small sample of these locations.

To control the shape of the information derived curves interest need only be limited to those management problems that will likely be of interest to top level management.

The perceptive reader with a statistical background may suggest that such information derived curves will have the hypothesized shape because they are constructed based on a technique similar to the statistical technique called discovery or exploratory sampling. An important difference, however, is that judgmental methods have been used to select locations believed to be representative of the total information system while for discovery sampling a probability (random) sample is used so that the laws of probability are operative.

Similarities between these judgmental and statistical methods are evident when the use of the information derived curve is considered. The curve may be used, as is the discovery sampling technique, to determine with reasonable assurance the number of sample locations needed to detect at least one speciman of the type of event sought.

By rearranging the data contained in Table 12, Table 18, page 122 is prepared.

TABLE 18

TABLE FOR SELECTING THE NUMBER OF LOCATIONS FOR AUDIT WHEN THE OBJECTIVE IS TO DETECT MANAGEMENT PROBLEMS THAT OCCUR AT TEN PERCENT OR MORE OF ALL LOCATIONS

- PHASE II RESEARCH -

(1) Number of Locations	(2) Known Range of The Percentage of Management Problems That Can Be Detected Using the Selected Number of Locations	(3) Average Percentage of Management Problems That Can Be Detected Using the Selected Number of Locations
1	30-41	35
2	47-63	55
3	60-82	72
4	75-89	83
5	79-93	87
6	81-94	89
7	82-95	90
8	84-96	92
9	89-98	94
10	89-99	95

To illustrate the use of the table, assume that audit managers decide to use a sample of seven locations. First locate the number seven under the first column of the table. Reading across note that judgmentally selected samples of seven locations have in the past detected from 82 to 95 percent of all reportable type items. On the average, 90 percent of the reportable type items may reasonably be expected to be detected. Conversely, assume that one wishes to use a judgmental sample of all locations that can be reasonably be expected to result in the detection of about 95 percent of all reportable type items. Reading down the third column of the table the desired percentage is located. Reading left across the row, one finds that a sample of 10 locations has a reasonable chance of providing the objective. In the past, from 89 to 99 percent of all reportable type items have been detected with that sample size.

Now note that by using a sample of ten judgmentally selected locations, one can reasonably expect to detect about 95 percent of <u>all</u> management problems that exist at ten percent or more of the universe of locations. One sample is used for the subject matter audit regardless of the actual or expected frequency among locations of the various management problems.

By contrast, had a randomly selected discovery sample of ten locations been used to detect at least one instance of a management problem that was known or expected to exist at exactly ten percent of the population of locations, then one could reasonably expect a 65.13 percent chance of being successful.[8] This is, of course, considerably less than the 95 percent detection rate achieved by a sample of 10 locations using the judgmental method. How can this difference in percentage be explained?

Two principal reasons can account for most of the difference. The difference in the method of selecting the samples, i.e. judgmental and random, and the difference in what is being measured. A full discussion of the difference that can be attributed to the method of selecting the sample is delayed until phase III of the research is presented. There this difference is examined in detail. Turning to the second reason, the following observations are made.

The judgmental sample is used to detect simultaneously a variety of management problems each of which is expected to occur at ten percent or more of all locations. The discovery sample is used to detect a single management problem that is expected to occur at exactly ten percent of all locations. If the actual incidence of the management problem among locations is greater than ten percent, then the resulting probability of detection with the same sample size will be greater than 65.13 percent.

In other words, if the information derived curves had been developed in phase II of the research using random rather than judgmental methods to select sample locations, then the curve would have been expected to rise at a rate rapid enough to reach a cumulative detection of 65 percent or more of the reportable type items by the tenth location.

Some estimation of the cumulative percentage of reportable type items that one might reasonably expect to detect with a random sample of ten locations may be made using the data contained in Table 19.

TABLE 19

ACTUAL FREQUENCIES OF REPORTABLE TYPE ITEMS

Frequency Range (Percent)	Number of Reportable Type Items at that Frequency Range			
	A_2	B_2	C_2	D_2
10 - 19	14	18	34	30
20 - 29	12	5	26	26
30 - 39	6	5	7	25
40 - 49	3	2	2	29
50 - 59	3	2	3	7
60 - 69	1	4	1	11
70 - 79	0	0	2	2
80 - 89	1	0	0	4
90 - 100	0	0	0	1
	40	36	75	135

Column 1 of Table 19, the "frequency range", provides a percentage range of locations applicable to the reportable type items detected. For example, for audit A_2 fourteen of the reportable type items were in evidence at from 10 to 19 percent of the universe of locations. Twelve other reportable type items were in evidence at from 20 to 29 percent of the universe of locations. The column total of 40 reportable type items for audit A_2 agrees with the number of reportable type items identified using definition

3 (refer to Table 6, page 94). Data for the remaining audits in Table 19 are similarly interpreted.

Now assume that a <u>single</u> discovery sample of ten locations is to be used to detect as many as possible of the 135 reportable type items listed in Table 19 for audit D_2. For the 30 reportable type items in the frequency range of 10-19, one would expect a detection rate of slightly better than 65 percent since the actual rate of occurrence of some of the items is greater than 10 percent. For the 26 reportable type items in the frequency range of 20-29, one would expect the detection rate to be even higher. For the one item in the 90-100 range, detection would be almost certain. For all items in aggregate, therefore, the detection rate should exceed 65 percent.

How much greater than 65 percent will this detection rate be? Research in phase III that follows will indicate that the detection rate using a random sample of 10 locations does not approximate the 95 percent detection rate achieved by a judgmental sample of 10 locations. Given that reportable type items have occurred with frequencies such as is shown in Table 19, a single random sample of locations should be successful in detecting only an average of about 80 percent of the items.

While the above arguments may be used to provide additional insight into the shape of the information derived curves, one should not overlook a serious problem that makes the discovery sampling approach undesirable. A separate sampling plan would have to be developed to test each suspected management problem to achieve individual results comparable to the results achieved by a single judgmental sample of a size determined through use of the data summarized in Table 18. That is, to ensure a 95 percent probability of detecting at least one of <u>each</u> reportable type item, the probable frequency of occurrence of that item in the universe of locations would have to be estimated and a separate random sample of sufficient size determined to yield the desired results. While it is, of course, possible to do this, it is not difficult to anticipate the additional administrative problems and costs that such extensive sampling plans for each subject matter audit would require. Since one of the objectives here is to find more economical methods of operation, this use of discovery sampling (to determine the number of locations to participate in a subject matter audit) is not further considered.

Returning to the results of the present research, what use can be made of data such as that contained in Table 18?

Three specific uses are suggested:

1. Assist in determining management areas in need of audit attention. Audit Programs for subject matter audits within the Air Force Audit Agency are centrally prepared by specifically assigned audit program writers. The programs are written to review management functions at the various operating locations around the world. Each subject matter audit, from initiation of the audit program to release of the final report of audit will, consume thousands of audit hours and require six months or more of a programmer's effort. Therefore it is vital that audit resources be expended in management areas that will produce results attractive to top level management. In the past, programs have been developed based upon subjective assessments that an area is in need of audit attention. However, by requesting deployed auditors to schedule locally short probing audits into an area being considered as a subject matter audit, it will be possible to assess objectively the need of a management area for a centrally controlled subject matter audit. For example, using the data of Table 18,

if auditors deployed at five locations are requested to review an area using locally scheduled time, one can be reasonably sure that 87 percent of all management problems that occur at ten percent or more of the universe of locations will be detected at one or more of the sample locations. These management problems would be noted by the audit program writer. The program for the complete subject matter audit would then concentrate in these areas, deleting those management areas where the objective facts about management operations do not support the subjective beliefs. This use of the information derived curve is explored in detail in Chapter V.

2. Assist in the management of field tests of new audit programs. Audit programs developed at a central location for application at operating levels of management are sometimes field tested at a small number of locations to ensure that the programs are understood and workable. The data of Table 18 suggests an additional use of the field test. If the number of bases selected for the test equal or exceed some reasonable

number, say five, then those portions of the audit program that were unproductive in detecting at least one instance of a management problem can be deleted from the program before it is applied on a full scale basis. The number of locations used in the field test and the extent to which portions of the program are deleted as being unproductive would be a subjective decision of the audit manager after considering the objective data of Table 18. The management of the field test of audit programs will be discussed in more detail in Chapter VI.

3. Assist in the accomplishment of segmented audits. A complaint sometimes heard from audit program writers and audit managers is that a certain area of management operation is in need of audit, but the area is so broad in scope that too many audit hours will be expended in its review. To preclude the excessive use of a limited supply of audit hours in a single management area, audit program writers of the Air Force Audit Agency are usually requested to prepare programs that will require from 200 to 300 audit hours for application at

each location. Consequently only portions of a management area rather than the total integrated function may be reviewed. By segmenting the audit, however, the complete management area may be reviewed while staying within reasonable limits in the consumption of audit hours. As an example, assume that a particular area of management operation could be expected to require 1500 audit hours for a comprehensive review. Assuming further that the management system is uniform between locations and is in use at a large number of locations, the audit may be divided or segmented into five portions, each requiring 300 audit hours to complete. Each of the five portions would be applied at a separate sample of locations. If each sample were ten locations in size, Table 18 indicates that approximately 95 percent of the management problems of interest will be detected. However, while it is important to know the extent to which the segmented audit detects the same reportable type items that would be detected in an audit of the universe of locations, of equal importance is to determine the comparative value of the information contained in the reports of audit. The feasibility of segmented audits is, therefore, also a function of the number of sample locations needed to produce a report of audit comparable to that produced in the universe audit. To determine the required member of sample locations is one function of the phase III research discussed in Chapter IV. The segmented audit is discussed in more detail in Chapter VII.

A final area of research concerns determining the percentage of information contained in the report of audit for each subject matter audit that could have been provided to operating managers from information derived from the sample of locations. The results of the research are recorded in Table 14. Since this area of research is examined in much more detail during phase III, an evaluation is made after the completion of that research.

Management Action

Following this research the Air Force Audit Agency implemented two sets of procedures that relate to, but do not take full advantage of, the research findings of phase I and II. These procedures were entitled "Program Audit

Development Survey (PADS)" and "Directed Audit Research Task (DART".

The purpose of the PADS was to apply the survey at a small number of bases to determine whether additional centrally directed audit effort was warranted. The procedures to be followed by the selected Auditor General Resident Offices (AGROs) were as follows:

a. Establish a PADS file.

b. Research AGRO permanent and current files on the activity to be reviewed. Prepare a workpaper showing the areas of the activity which have been audited in the past 12 months (time frame may be expanded if productive local audits have been accomplished previously). Include a synopsis of the significant findings reported.

c. Review audit need files and include appropriate information in the PADS workpaper file.

d. Review pertinent directives encompassing those areas which experience has shown to be productive, as well as unfamiliar areas which may have audit potential.

e. Based on results of (b) - (d) above and personal knowledge, prepare a list of specific areas which may warrant a further centrally directed audit effort. This list may go beyond the objectives stated in the notification.

f. Based on (e) above, develop a survey plan or outline; and, using appropriate survey methods, accomplish a survey of the areas listed. Prepare workpapers in detail to show the extent of the survey and findings.

Those areas which appear to warrant further review should be annotated. Also record areas found deficient in the past.

g. Develop specific objectives and audit steps in those areas which warrant further review. Do not develop audit steps for those areas where the survey produced insignificant findings. Use imagination in developing audit steps. Do not go by directive requirements alone. A prime objective of PADS is to develop fruitful audit steps in indicated problem areas.

h. Using the audit steps developed in (g) above, accomplish an audit of the areas selected. Continually refine the objectives and audit steps until satisfied that the objectives are the most productive and the audit steps are the best method for meeting the objectives. The workpapers should show in detail the original objectives and audit steps; results of initial application; any revisions/refinements to objectives or audit steps and reasons; results of audit; and suggestions and reasons for including or excluding the area(s) in further centrally directed audit effort.[9]

As may be noted, the general spirit of the research effort is reflected but full advantage is not taken to achieve the precision of results that are possible by specifying the number of AGROs that should participate in each PADS or otherwise using such data as is contained in Table 18.

The Directed Audit Research Task procedures also had the objective of identifying for planning purposes, areas for profitable application of audit effort.[10] But again, as of the date of this writing full advantage had not been taken of the new management tools provided by this research.

Additional Research Needed

Although a considerable amount of useful information for the management of internal audit resources has been provided in the first two phases of the research, additional research is needed to refine the information and to answer some questions that remain. For example, how many sample audit locations are enough to provide an audit report comparable with the report achieved by the all-location audit? Is there a point or range within the sample at which the incremental cost of information begins to exceed its incremental value? Does an empirical study of the records indicate that a judgmental selection of locations is superior to a random selection of locations when the objective is early detection of significant management problems. If a judgmental selection of locations is used, what criteria should be used for the selection?

To answer these and other questions, phase III of the research is now considered.

FOOTNOTES

1. Note that the vertical axis is labeled "Cumulative Percentage of Information Derived." In subsequent discussions of the information derived curve interest will be in a specific kind of information called a "reportable type item." However, for the present discussion the general term "information" is used to simplify the introductory comments.

2. David B. Guralnik, Webster's New World Dictionary, Second College Edition (New York and Cleveland: The World Publishing Company, 1970), p. 445.

3. Ibid.

4. Chris Argyris, Integrating the Individual and the Organization, John Wiley and Sons, Inc., New York, London, Sydney, 1966, p. 123.

5. Chester I. Barnard, The Functions of the Executive, Harvard University Press, Cambridge, Massachusetts, 1970, pp. 19 and 60.

6. Ibid., p. 60.

7. Committee on Accounting Concepts and Standards, 1957 Revision, The Accounting Review, October, 1957, pp. 538-546.

8. A more complete discussion of discovery sampling is contained in the following reference: Herbert Arkin, Handbook of Sampling for Auditing and Accounting, McGraw-Hill Book Company, Inc., New York, 1963, pp. 144-154. Note particularly the formula contained in footnote 7, page 150.

9. Air Force Audit Regulation 175-101, Internal Audit Procedure, Norton Air Force Base, California, 1969, pp. 4-1 thru 4-2.

10. Air Force Audit Regulation 175-105, Directed Audit Research Task, Norton Air Force Base, California, 1970.

CHAPTER IV

RESEARCH -- PHASE III

The primary purpose of this chapter is to discuss the derivation and use of the information derived curve in considerable detail beyond that covered in the first two phases of the research. To provide this discussion, the chapter is divided into seven sections. The first section outlines the specific objectives of the research contained in the chapter. Sections two through four define the reportable type items measured and describe the method used to select the subject matter audits and audit locations for analysis. The research plan is outlined in section five and is followed by a description of the research results. The chapter concludes with an evaluation of these results.

The Objectives

Specific objectives for this phase of the research were as follows:

1. To establish beyond a reasonable doubt the shape of the information derived curve.

Although audit managers specified during phase II of the research that the analysis of the data for four additional subject matter audits would be sufficient to indicate the true shape, data for nine additional subject matter audits are analyzed to remove any doubt as to the shape of the curve from the most skeptical of observers.

2. To determine if there is a statistically significant difference between information derived curves developed using audit data generated at locations judgmentally selected as being representative of the population of locations, and those curves developed using audit data generated at locations randomly selected from the population of locations. It has been argued (see pages 79-87) that, conceptually, if the subject matter audit is to be restricted to a number of locations significantly less than the population of locations, then audit locations judgmentally selected as being most representative of the total information system being audited will provide more useful information to top level managers than will audit

locations randomly selected. To test this conceptual argument information derived curves are constructed for the nine subject matter audits mentioned in objective one above using both judgmental and random selection techniques to determine if one technique is statistically superior.

3. To identify criteria to select judgmentally audit locations from the universe of locations. As previously stated, with regard to using a judgmental approach to select the sample, there is a central guiding criterion. The specific locations should be chosen in such a way as to provide information to top management which is representative of the total information system under audit.

4. To extend knowledge concerning the percentage of information contained in the report of audit for the subject matter area that could have been reported based on information derived from judgmentally selected samples of five, ten, and fifteen locations.

5. To determine a range of locations for an audit for which cost can be considered reasonable --

a range beyond which the incremental cost of audit tends to exceed the value of the incremental information.

6. To develop, based upon an analysis of empirical data, a table that will provide audit managers a means of objectively determining the number of sample locations needed from a universe of locations to discover a specified portion of all reportable type items. While the data in the tables do not result entirely from the use of probability or purely statistical techniques, they do provide an empirical management tool that can be used with an acceptable degree of precision -- a tool that can be used to achieve auditing economy.

The Reportable Type Items

As defined previously, reportable type items are in general those items of information that are disclosed by a subject matter audit and inform top levels of management of non compliance with managerial directives or of poor management practices.

For this phase of the research, as was the case with phase I and II, an item of information must meet two specific criteria to be classified as a reportable type item. First, each item of information must be separate and distinct from every other item of information. Repeating an earlier example, one item may be that physical inventory counts made by auditors do not match balances recorded in perpetual inventory records maintained by managers. The second criterion is that the information must relate to inaccurate or undesirable actions that occur with a minimum frequency within the total subject matter audit. Specifically "minimum frequency" here relates to operating errors or poor management practices that are observed to occur at at least ten percent or more of the locations in the universe of locations. This definition of minimum frequency coincides with definition 3, phase II of the research and is the one audit managers believe will encompass the type of problems of interest to top level managers.

Selection of Subject Matter Audits

While the accomplishment of all of the objectives for this phase of the research is to some extent dependent upon the number of subject matter audits analyzed, two objectives are particularly dependent. These are: (1) to establish beyond a reasonable doubt the precise shape of the information derived curve, and (2) to determine if there is a significant statistical difference between information derived curves developed from audit data generated at locations judgmentally selected, and those generated at locations randomly selected from the universe of locations.

A review of the audit files at the Air Force Audit Agency disclosed that the supporting data for nine subject matter audits that were applied at 40 or more locations were on hand. Supporting data for other subject matter audits that would have been of interest to this research had been destroyed in accordance with normal operating procedure.

The supporting data for all nine subject matter audits were requested. Nine additional determinations of the information derived curve should provide convincing evidence as to the shape of the curve. By combining the results of the phase III research with that of phase II, a total of thirteen curves will be available for analysis -- more than three times the number that audit managers originally suggested. Further, nine comparisons should be sufficient to determine if the information derived curve developed from judgmental selection of individual audit locations is significantly superior (α = .10) to such curves developed from random selection of individual audit locations.

Supporting data for the following completed subject matter audits were provided:

TABLE 20

SUBJECT MATTER AUDITS -- PHASE III

(1) Audit Area	(2) Judgmental Method Code	(3) Random Method Code	(4) Number of Audit Locations
NCO Open Mess	AJ	AR	70
Officer's Open Mess	BJ	BR	67
Aero Club	CJ	CR	52
Central Base Fund	DJ	DR	123
Billeting Fund	EJ	ER	96
Rod and Gun Club	FJ	FR	42
Fiscal Control Office	GJ	GR	105
Welfare Funds	HJ	HR	122
Private Association Funds	IJ	IR	122

Column (1) identifies the audit area of each subject matter audit. Column (2) provides a code for identifying each subject matter audit when judgmental methods are used to select a sample of locations from the universe of locations used in the complete audit. Reading down the column, the first letter of each code spans the alphabetical sequence A-I. The second letter, the letter "J", denotes that the judgmental method for selecting a sample of audit locations is used. Reading down column (3), the first letter of each code also spans the alphabetical sequence A-I. The second letter, however, is "R". This letter denotes that random selection methods are used to select samples of audit locations from the universe of locations used in each completed subject matter audit. Column (4) indicates the size of the universe of locations for each subject matter audit used in the analysis.

Selection of Sample Locations

The selection of sample locations involves two decisions -- the number of selections to include in each sample and the method to use to make the selections.

The number of selections to include in each sample must be sufficient to provide data that will allow accomplishment of the research objectives. A review of these objectives discloses that the accomplishment of two objectives in particular is dependent upon the size of each sample of locations. They are: (1) to extent knowledge as to the amount of material information that is available from small samples of audit locations, and the related objective, (2) to determine a sample range beyond which the incremental cost of audit tends to exceed the value of the incremental information.

In phase II of the research the size of each judgmentally selected sample was limited to 10 locations. Analysis of the sample data for four subject matter audits provided a considerable amount of information as to the percentage of reportable type items that should be detected using various sample sizes, and as to the percentage of information contained in the report of audit that could have been provided to operating managers based on information derived from the sample of locations. These statistics are provided in Table 18, page 122, and in Table 14, page 101 respectively.

The statistics in Table 18 and Table 14 indicate that a high percentage of information is present in a sample size of 10 locations. Table 18 indicates that on the average, about 95 percent of all reportable type items that will occur at ten percent or more locations in the universe of locations for each subject matter audit should be detected. An empirical analysis of past audit data indicates that the range of such detection spans from no worse than 89 percent to as high as 99 percent detection. Table 14, on the other hand, indicates that about 73 percent of the information contained in the report of audit is also of sufficient materiality in the sample of locations to warrant inclusion in a report of audit.

Considering these high percentages already achieved by sample sizes of 10 locations and the objectives sought, sample sizes for phase III of the research were extended from 10 to 15 locations each on the assumption that a 50 percent increase in sample size should be sufficient to achieve these objectives.

Now consider the second of the two decisions -- the method to use to make the sample selections. To meet the second objective of this phase of the research -- to determine if there is a significant statistical difference between information derived curves resulting from information derived from locations randomly selected and from information derived from locations judgmentally selected -- for each of the nine subject matter audits two samples of 15 locations each must be selected.

One sample must be randomly selected. To select this sample, each of the locations in the universe of locations was numbered. Random number tables were then used to identify those locations included in the sample. Data for these sample locations were analyzed in the order as identified by the random number listings. For example, Table 20 indicates that audit AR was applied at a total of 70 locations. If the first random number identified from the random number table were 31, then audit data from that location were analyzed first. If the second random number were 12, then audit data from that location were analyzed next, and so on, until the sample of 15 locations was completed and the resulting information derived curve constructed.

The other sample must be judgmentally selected. In an earlier discussion in the previous chapter, it was pointed out that, with regard to using a judgmental approach to selecting the sample, there is a central guiding criterion. The specific locations should be chosen in such a way as to provide information to top management which is representative of the total information system under audit.

For illustrative purposes, it was assumed that the auditor wishes to select a number of Air Force bases at which to review a particular system in operation. It was stated that his selection of the particular locations or bases would depend upon answers to such questions as:

1. Who requested that this audit be performed?
2. Why did that request originate?
3. What specific problem or information need prompted the request (to what use will the report be put)?
4. Is the information need peculiar to a given

portion of the total information system of the Air Force?

5. Are matters dealing with system design, policies, and operations within the system sufficiently uniform so as to be able to make judgments about the total system on a less than total system examination?
6. How many bases are likely candidates for the application of the audit program?
7. What are the characteristics of the bases which bear upon their role in this information system (size, command, etc.)?
8. At which bases will the system be the most representative of the Air Force-wide system?
9. In what form should the recommendations be made?

Top management must receive results of audit oriented to a total system; it follows that the sample should be selected in such a manner that the bases used for audit application will have operations which are deemed to be representative of the total system. Answering such questions as listed above is not easy, for specific guidelines are hard to state. Some scheme for classifying bases by the nature of their participation in the information system must be used. Some of the classification parameters could be the size of the system at the base, the volume of paperwork handled, the techniques for information processing, whether the base is domestic or foreign, the major command to which the base is assigned, and experience of the auditor making the audit. All of the parameters are the type of characteristics which lead to formal stratification when statistical sampling is used. In a similar way, they should influence the selection of the bases for audit application on a judgmental basis.

In both phase I and II of the research no attempt was made to identify the selection criteria used by audit managers in selecting the locations used in each phase of the analysis. To provide representative rather than biased results, audit managers in making their selections were requested to ignore as much as possible hindsight knowledge of audit findings at specific locations. But again, no attempt was made to control specifically for such knowledge.

In this phase of the research we wish both to identify the selection criteris used by audit managers to select each of the nine samples of 15 locations, and if necessary to control for hindsight knowledge of actual results.

The development of methods to control for knowledge of actual results did not prove necessary for the nine subject matter audits selected for analysis. Audit managers for the areas covered by the audits were either newly assigned or sufficiently unfamiliar with the past results of each specific audit to exhibit any significant bias in the selection of locations. Specifically, seven of the nine samples were selected by audit managers who did not work on the original summarization of audit results. The remaining two samples were selected by an audit manager who had worked on the summarization of the original audit results, however, the summarization had taken place more than a year prior to the current review.

The judgmental selection of the individual audit locations to be included in the sample of locations could not be made with a great deal of objectivity. There were no established criteria providing objective measurements to use in the selection process. Audit locations for past centrally directed audits were selected with the primary objective of assuring an appropriate distribution of directed audits across Audit Regions and among assigned Auditor General Resident Offices. Other considerations for the location selections were secondary to this stated policy.[1] With this policy, there is no pressing need to develop quantifiable measures to select specific locations to participate in a particular subject matter audit based on how well they represent the system to be audited.

However, for this phase of the research it is desired to emphasize the selection of locations which are deemed to be representative of the total system to be audited rather than upon a "share the work" philosophy. Therefore, some criteria to guide these individual selections must be identified.

An obvious approach to identifying the selection criteria is to interview the audit managers responsible for the centrally directed audits accomplished in their assigned subject matter areas. And indeed this is done. However, the experienced auditor within the Air Force Audit Agency realizes that the audit manager position is not a position that one develops throughout an auditing career. The position is usually occupied by an auditor who is rotated into and eventually out of the assignment. While in the assignment, he currently may not have much more information about the merits of including certain locations in a subject matter audit than do the Audit Region personnel responsible for the daily supervision of the audit activities at these locations.

Therefore the selection criteria were developed as follows. The chief and/or supervisory auditors of the

Western, Central, and Eastern Audit Regions were interviewed in person or by telephone to determine their suggestions for appropriate criteria. Specifically, personnel at each Audit Region were asked to provide a list of from five to seven locations that they would suggest as a sample of locations to review each of the nine subject matter areas included in the analysis of this phase of the research. They were then asked to identify the criteria used to select those specific locations.

Next, audit managers were interviewed to determine the criteria they would use in selecting a representative sample of locations from the universe of locations at which the subject matter audits were applied.

Based on both of these interviews a suggested list of general criteria was developed. These criteria together with explanatory comments, where appropriate, are as follows:

1. Select locations that will provide audit data that will most likely satisfy the information needs of top level managers. This criterion was generally accepted as being the primary consideration.
2. Select those locations that have the best qualified audit staffs to review the information system of interest. Ideally some form

of a monitoring system would be needed to keep track of the most qualified auditors for specific subject matter areas. A variety of control techniques may be suggested ranging from formalized and computerized personnel records to the subjective judgments of audit managers. As an example, one very simple subjective technique was suggested by one audit manager to identify the most productive, and perhaps therefore the most qualified staffs. His suggestion was to open the file drawers and identify those locations that have in the past consistently issued the thicker local audit reports. His premise was that the thicker reports are more likely a function of a more careful conscientious auditor rather than of a function of the system location.

3. Select locations that provide general representation of the larger Air Force commands.

4. Select locations at which activity in the system to be audited is high relative to other potential locations.

5. Select those locations where the Resident Auditor will have time to supervise the

project adequately. This criterion was, understandably, originally suggested by Audit Region personnel who have primary overall supervision responsibility of the audit efforts at the Auditor General Resident Offices. In view of the large numbers of relatively untrained junior auditors on most auditing staffs, however, the logic of the criterion is self-evident.

Considering the above criteria, audit managers were asked to select for each of the nine subject matter audits in this analysis the 15 locations, ranked in order from 1 to 15, that they would have recommended for inclusion in each subject matter audit had the audit been restricted to 15 locations. The criteria were considered simultaneously in making the selections. To aid in the ranking process, audit managers were asked to select each of the fifteen locations in three groups of five, that is the first five would be selected and ranked first, then the second five, and finally the last five for a total of 15.

It is hypothesized that if the selection criteria are appropriate and if they have been applied properly by audit managers, then information derived curves resulting from analyzing audit data from the locations in the order ranked will initially rise somewhat faster as additional locations are added to the sample of locations than will such curves resulting from analyzing audit data from these same locations but in the reverse order of their ranking, i.e. the fifteenth location becomes the first, the fourteenth becomes the second, and so on. This hypothesis is tested in the following research.

The Research

The nine subject matter audits analyzed in this phase of the research were originally applied at a total of 799 locations. Supporting data for the audits at these locations were analyzed to determine the total number of reportable type items for each subject matter audit.

Information derived curves were constructed for each of the nine subject matter audits using both judgmental and random selection methods previously described. These curves were compared to determine if one method of constructing the curves was statistically superior to the other method. Additionally, data used to construct information derived curves using the judgmental method were reversed in order. These data were used to construct "reverse order" information derived curves for comparison with the original curves to determine the effectiveness of the criteria used to judgmentally select and rank the original locations.

An analysis was made to determine what percent of the information contained in the final report of audit for the subject matter audit could have been provided to operating managers based on information derived from the sample of locations. The percentage was determined at the end of the first five locations, at the end of the tenth location, and at the end of the fifteenth location for each sample of locations.

To make this analysis in a quantifiable manner, the objective criteria used in phase II of the research (refer to Table 5, page 91) were also used in this phase of the research to judge the materiality of the reportable type items found in each sample, with one exception. The factor tests for materiality were expanded to encompass fifteen location samples.

Specifically, the general guide used to judge the materiality of reportable type items found in the sample of locations is as shown in Table 21, page 158. Further, as in phase II of the research, two additional actions were taken to ensure comparability between the information contained in the report of audit and that provided by the sample of locations. First, the frequency of occurrence

TABLE 21

FACTOR TESTS FOR MATERIALITY - PHASE III

Factor	Five Location Sample	Ten Location Sample	Fifteen Location Sample
Frequency	Two or more locations	Three or more locations	Four or more locations
Magnitude	Ten percent, or if less than ten percent, equal to the reported percentage.	Ten percent, or if less than ten percent, equal to the reported percentage.	Ten percent, or if less than ten percent, equal to the reported percentage.

of all reported information was reviewed. Those reported management problems that occurred at less than ten percent of the universe of locations were dropped from further consideration. Such problems would not qualify as reportable type items for the information derived curve of primary interest. And second, if the data provided by the sample of locations failed the test for materiality specified in Table 21, one additional test was given. The frequency and magnitude of the data in the sample was compared with the frequency and magnitude of the reported information in the universe. If both the frequency and magnitude of the data in the sample was equal to or greater than that from the universe, the sample information was judged to be reportable. This latter modification to the materiality criteria was made so that management problems of a sensitive nature that perhaps need not occur as often as other problems to be of concern to top management are given equal consideration both in the universe of locations and in the sample of locations.

Finally, the "cost of sampling curve" originally introduced in Figure 2, page 11, was developed and constructed. The curve was separately matched against, first, a curve which traced the average percentage of reported information available from samples of five, ten, and fifteen locations, and second, against the average percentage of reportable type items detected over the span of a 15 location sample. A range of sample sizes was identified beyond which the incremental cost of audit tended to exceed the value of the incremental information.

Results of the Research

An analysis of the audit data generated from the total of 799 locations at which the nine subject matter audits were applied disclosed the following numbers of reportable type items:

TABLE 22

REPORTABLE TYPE ITEMS -- PHASE III

Audit Code	Number of Reportable Type Items
A	45
B	32
C	35
D	45
E	30
F	41
G	10
H	6
I	9

Note that the audit codes A-I do not contain a second letter "J" or an "R". The method for selecting a sample of audit locations has no effect on the number of reportable type items in each subject matter audit.

In constructing the information derived curves, the cumulative number of reportable type items that could be detected from a sample of fifteen locations using both judgmental and random methods for selecting each sample was determined.

Consider first the judgmental method of selection. The cumulative number of these reportable type items detected by the judgmental sample of fifteen locations for each of the nine subject matter audits is recorded in Table 23, page 163.

Table 23 provides absolute numbers of reportable type items. Since the total of reportable type items for each subject matter audit differs, here ranging from 6 to 45, it may be difficult for the observer to determine the rate at which new information is being accumulated as locations are added to the sample. It may be easier to visualize this rate if the data for each subject matter audit is converted into a common measuring device. This is done in Table 24, page 164, by converting the absolute numbers of Table 23 to common percentages.

As an aid in visualizing this data, Figure 14, page 166 is prepared. To draw the individual information derived curves for nine subject matter audits would result in a figure difficult to interpret. Therefore, Figure 14 contains only three composite information derived curves formed from the best, worst, and average percentage data in Table 24. Although the data for the composite information derived curves are abstracted from Table 24, the maze of information within that table makes it difficult to determine at a glance which data are appropriate. To simplify this presentation, Table 25, page 165 provides the specific information by type of percentage and by location.

For the random method of selection, the same data arrangements are provided. The cumulative number of reportable type items found is contained in Table 26, page 167. The cumulative percentage of reportable type items is shown in Table 27, page 168. Data recorded in Table 28, page 169, is illustrated in Figure 15, page 170.

To illustrate the interpretation of the above data, consider the information contained in Figures 14 and 15. Figure 15 indicates that by the eighth location, the best results achieved by a sample of locations randomly selected from the universe of possible locations is a detection of all or 100 percent of the reportable type items. The

TABLE 23

CUMULATIVE NUMBER OF REPORTABLE TYPE ITEMS FOUND - JUDGMENTAL METHOD

Audit Code	Total Items (Table 22)	Locations														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
AJ	45	12	18	21	25	32	36	36	36	38	39	40	40	40	41	41
BJ	32	13	18	20	22	24	27	30	30	31	31	31	31	31	31	31
CJ	35	18	20	22	28	30	31	33	33	33	33	34	34	34	34	34
DJ	45	17	24	27	31	32	34	36	38	40	42	43	43	43	44	44
EJ	30	9	14	19	21	21	24	25	25	28	28	28	28	28	28	28
FJ	41	14	24	31	34	34	39	40	40	40	40	40	40	40	40	40
GJ	10	3	6	6	7	7	7	7	8	9	9	9	9	10	10	10
HG	6	1	4	4	4	4	4	5	6	6	6	6	6	6	6	6
IJ	9	3	9	9	9	9	9	9	9	9	9	9	9	9	9	9

TABLE 24

CUMULATIVE PERCENTAGE OF REPORTABLE TYPE ITEMS FOUND - JUDGMENTAL METHOD

Audit Code	Locations														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
AJ	27	40	47	56	71	80	80	80	84	87	89	89	89	91	91
BJ	41	56	63	69	75	84	94	94	97	97	97	97	97	97	97
CJ	51	57	63	80	86	89	94	94	94	94	95	97	97	97	97
DJ	38	53	60	69	71	76	80	84	89	93	96	96	96	98	98
EJ	30	47	63	70	70	80	83	83	93	93	93	93	93	93	93
FJ	34	59	76	83	83	95	98	98	98	98	98	98	98	98	98
GJ	30	60	60	70	70	70	70	80	90	90	90	90	100	100	100
HJ	17	67	67	67	67	67	83	100	100	100	100	100	100	100	100
IJ	33	100	100	100	100	100	100	100	100	100	100	100	100	100	100

TABLE 25

*DATA FOR COMPOSITE INFORMATION DERIVED CURVES - JUDGMENTAL METHOD

	Locations														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Best Percentage	51	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Worst Percentage	17	40	47	56	67	67	70	80	84	87	89	89	89	91	91
Average Percentage	36	54	63	72	76	83	87	89	92	94	95	95	95	96	96

*Derived from Table 24.

FIGURE 14

COMPOSITE INFORMATION DERIVED CURVES FORMED FROM THE BEST, WORST, AND AVERAGE PERCENTAGE OF DATA IN TABLE 25

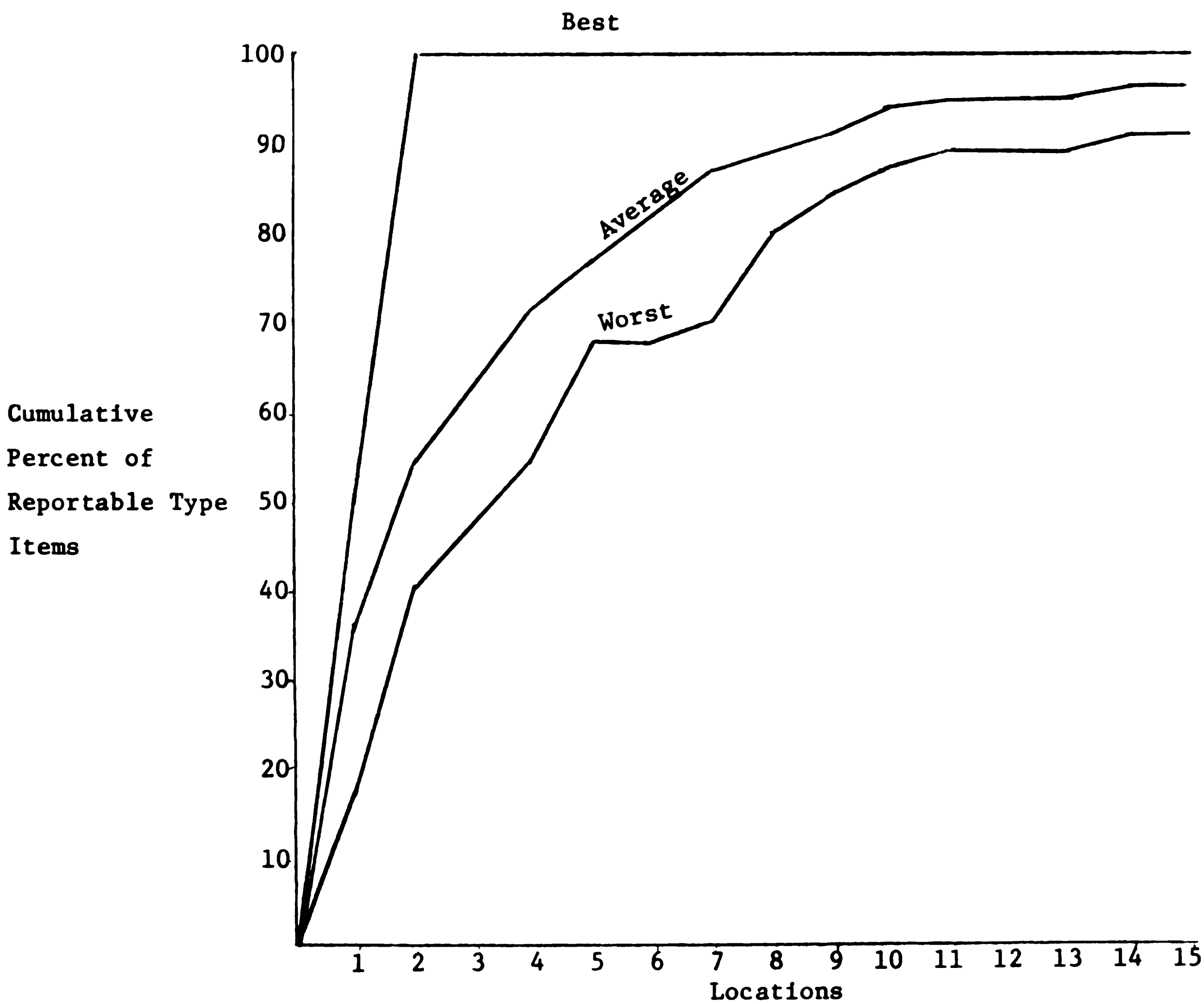


TABLE 26

CUMULATIVE NUMBER OF REPORTABLE TYPE ITEMS FOUND - RANDOM METHOD

Audit Code	Total Items (Table 22)	Locations														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
AR	45	8	10	12	13	17	20	24	25	25	33	33	36	39	39	40
BR	32	0	3	13	20	22	23	23	24	24	24	27	29	29	30	30
CR	35	1	2	10	13	16	16	19	20	22	25	28	29	30	31	32
DR	45	7	11	19	30	31	31	31	32	34	35	39	39	39	41	43
ER	30	7	9	10	14	16	19	21	23	23	24	24	24	24	26	27
FR	41	10	13	17	18	20	30	31	34	35	35	35	35	35	35	39
GR	10	0	0	1	1	2	2	2	3	7	7	7	8	8	8	8
HR	6	1	1	2	2	2	2	2	3	5	5	6	6	6	6	6
IR	9	0	8	9	9	9	9	9	9	9	9	9	9	9	9	9

TABLE 27

CUMULATIVE PERCENTAGE OF REPORTABLE TYPE ITEMS FOUND - RANDOM METHOD

Audit	Locations														
Code	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
AR	18	22	27	29	38	44	53	56	56	73	73	80	87	87	89
BR	0	9	41	63	69	72	72	75	75	75	84	91	91	94	94
CR	3	6	29	37	46	46	54	57	63	71	80	83	86	89	91
DR	16	24	42	67	69	69	69	71	76	78	87	87	87	91	96
ER	23	30	33	47	53	63	70	77	77	80	80	80	80	87	90
FR	24	32	41	44	49	73	76	83	86	86	86	86	86	86	95
GR	0	0	10	10	20	20	20	30	70	70	70	80	80	80	80
HR	17	17	33	33	33	33	33	50	83	83	100	100	100	100	100
IR	0	89	100	100	100	100	100	100	100	100	100	100	100	100	100

TABLE 28

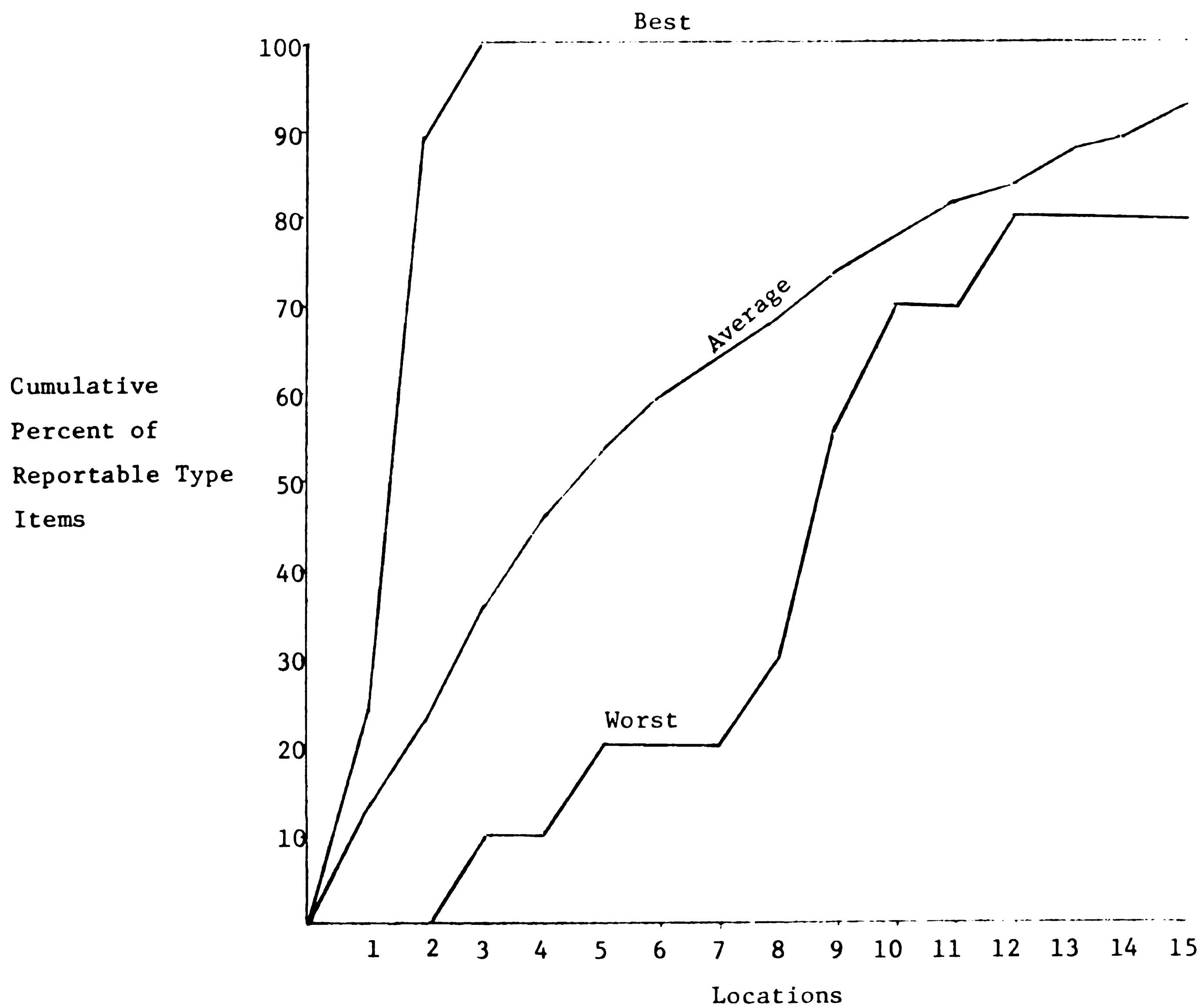
*DATA FOR COMPOSITE INFORMATION DERIVED CURVES - RANDOM METHOD

	Locations														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Best Percentage	24	89	100	100	100	100	100	100	100	100	100	100	100	100	100
Worst Percentage	0	0	10	10	20	20	20	30	56	70	70	80	80	80	80
Average Percentage	13	23	37	47	53	60	64	68	73	78	82	83	87	89	93

*Derived from Table 27.

FIGURE 15

COMPOSITE INFORMATION DERIVED CURVES FORMED FROM THE BEST, WORST, AND AVERAGE PERCENTAGE OF DATA IN TABLE 28



average results achieved by random samples for the nine subject matter audits included in the analysis is a detection of 68 percent of the reportable type items. The worst results by the eighth location is a detection of 30 percent of the items. The spread between the best and worst rate is 70 percent.

By constrast, Figure 14 indicates that by the eighth location, the best results achieved by a sample of locations judgmentally selected from the universe of possible locations is also a detection of 100 percent of the reportable type items. The average results achieved by judgment samples for the nine subject matter audits is a very high detection rate of 89 percent while the worst result is a detection rate of 80 percent. The spread between the best and worst rate is only 20 percent.

The specific evaluation of these results in terms of their implication for the management of internal audit resources is discussed in the next section of this chapter.

As for now, the results of another area of the research is reviewed. The purpose here is not only to construct the information derived curves as has just been done, but to compare the curves to determine if each curve constructed using the judgmental method for sample selection provides statistically superior results in detecting reportable type items to the results achieved by each curve constructed using a random method for sample selection. Additionally, we wish to present data that will indicate the effectiveness of the criteria used to judgmentally select and rank the sample locations for each of the nine subject matter audits.

This is done in Table 29, pages 173-174. Table 29 provides the cumulative percentage of reportable type items detected by method by location. The first column of the table identifies by code the nine subject matter audits used in the analysis. The second column lists three methods called "judgment", "reverse", and "random". The judgment method refers to the manner of selecting each sample of 15 locations as does the random method. The reverse method, however, applies to a rearrangement of the sample locations used in the judgment method. Specifically, the sample locations of the judgment method are reversed in order before the audit data are analyzed. That is, the fifteenth location identified for the judgment method is made the first location of the reverse method, the fourteenth location of the judgment method is made the second location of the reverse method, and so on. The final section headed "locations" contains the cumulative percentages of the information derived curve for each given audit and

TABLE 29

CUMULATIVE PERCENTAGE OF REPORTABLE TYPE ITEMS DETECTED
BY METHOD BY LOCATION

(1) Audit Code	(2) Method	(3) Locations 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
A	Judgement	27	40	47	56	71	80	80	80	84	87	89	89	89	91	91
	Reverse	2	9	42	56	69	76	78	78	82	84	84	91	91	91	91
	Random	18	22	27	29	38	44	53	56	56	73	73	80	87	87	89
B	Judgement	41	56	63	69	75	84	94	94	97	97	97	97	97	97	97
	Reverse	9	28	34	53	56	69	72	81	91	97	97	97	97	97	97
	Random	0	9	41	63	69	72	72	75	75	75	84	91	91	94	94
C	Judgement	51	57	63	80	86	89	94	94	94	94	97	97	97	97	97
	Reverse	14	17	34	34	37	46	57	66	74	80	91	91	91	94	97
	Random	3	6	29	37	46	46	54	57	63	71	80	83	86	89	91
D	Judgement	38	53	60	69	71	76	80	84	89	93	96	96	96	98	98
	Reverse	2	11	31	56	69	78	84	89	89	89	91	96	98	98	98
	Random	16	24	42	67	69	69	69	71	76	78	87	87	87	91	96

TABLE 29--Continued

(1) Audit Code	(2) Method	(3) Locations 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
E	Judgement	30	47	63	70	70	80	83	83	93	93	93	93	93	93	93
	Reverse	17	27	53	60	70	77	77	83	90	90	90	90	90	90	93
	Random	23	30	33	47	53	63	70	77	77	80	80	80	80	87	90
F	Judgement	34	59	76	83	83	95	98	98	98	98	98	98	98	98	98
	Reverse	20	51	56	56	56	68	71	73	80	80	90	90	90	98	98
	Random	24	32	41	44	49	73	76	83	86	86	86	86	86	86	95
G	Judgement	30	60	60	70	70	70	70	80	90	90	90	90	100	100	100
	Reverse	0	10	10	10	30	40	60	70	70	70	70	80	80	100	100
	Random	0	0	10	10	20	20	20	30	70	70	70	80	80	80	80
H	Judgement	17	67	67	67	67	67	83	100	100	100	100	100	100	100	100
	Reverse	0	0	0	0	50	50	67	100	100	100	100	100	100	100	100
	Random	17	17	33	33	33	33	33	50	83	83	100	100	100	100	100
I	Judgement	33	100	100	100	100	100	100	100	100	100	100	100	100	100	100
	Reverse	56	56	78	89	89	89	89	89	89	100	100	100	100	100	100
	Random	0	89	100	100	100	100	100	100	100	100	100	100	100	100	100

method.

To illustrate the use of the table, consider the data provided for subject matter audit B. When the judgment method for selecting the audit locations is used, 41 percent of the reportable type items contained in the universe of locations is detected at the first location. At the second location an additional 15 percent of the reportable type items from the universe of locations, but not detected at the first location, are in evidence for a cumulative detection of 56 percent of the items over the first two locations. By the eighth location, 94 percent of all reportable type items in the universe of locations are detected. The percentages recorded by location for the reverse and random methods are interpreted in the same way.

Obviously the data are now available both to compare the effectiveness of judgment and random sample selection methods, and to make some assessment of the effectiveness of the criteria used to select and rank locations when the judgment method is used. However, as was the case with the data relating to the shape of the information derived curves, evaluation of these data is delayed and discussed in the next section of this chapter.

To this point the results of research that will allow one to establish beyond a reasonable doubt the shape of the information derived curve, to determine if there is a significant statistical difference between information derived curves developed using audit data generated at locations judgmentally selected as being representative of the population of locations, and those curves developed using audit data generated at locations randomly selected from the population of locations, and to assess the effectiveness of the criteria used to judgmentally select audit locations from the universe of locations have been presented. Now we will consider the results of research that should allow the extension of knowledge as to the amount of material information that is available from small samples of audit locations, and the establishment of a range of the number of sample locations that should be used for each subject matter audit.

In outlining the phase III research, it was stated that an analysis was made to determine what percent of the information contained in the final report of audit for the subject matter audit could have been provided to operating managers based on information derived from the sample of locations. The percentage was determined at the end of the first five locations, at the end of the tenth location, and at the end of the fifteenth location for each sample of locations. To judge the materiality of the information detected by each sample of locations, tests described on Table 21, page 158 were used.

The results of this analysis are provided in Table 30, page 178. Note that the table contains the combined data of both phase II and III of the research since the criteria for evaluating the information are identical.

To illustrate the use of this table, consider the data recorded for subject matter audit AJ. Had the subject matter audit been restricted to five judgmentally selected locations, these five locations would have provided sufficient material information to report 56 percent of the total information that was included in the report of audit for the complete subject matter audit. Had the number of locations in the judgmental sample been expanded to ten, the amount of reportable information would have been 71 percent. For fifteen locations, 84 percent of the reported information could have been provided. On an average, about 71 percent of the information contained in the report of audit could be reported using a five location sample. For ten and fifteen location samples, these percentages are 80 and 95 percent respectively. While an audit manager may be comfortable with the averages based on these actual results, the very cautious might reasonably ask what are the lowest percentages of information that the analysis

TABLE 30

PERCENTAGE OF REPORTED INFORMATION
AVAILABLE FROM SAMPLES

Audit Code	Sample Size		
	Five Locations	Ten Locations	Fifteen Locations
AJ	56	71	84
BJ	59	69	90
CJ	80	80	100
DJ	50	61	83
EJ	50	75	100
FJ	100	100	100
GJ	100	100	100
HG	50	100	100
IJ	100	100	100
A_2	63	73	
B_2	68	74	
C_2	73	73	
D_2	70	70	
Average:	71	80	95
AR	7	27	36
BR	28	31	69
CR	0	20	20
DR	28	44	83

indicates are present? These percentages are 50 percent at five locations, 61 percent at 10 locations, and 83 percent at fifteen locations -- still an extremely high percentage of reportable information from a very low percentage of the universe of audit locations. Finally, for comparison purposes, the last four lines of Table 30 provide for four subject matter audits, the percentages of information that could have been reported had random methods been used to select the audit locations.

To determine a range of locations for a given subject matter audit for which cost can be considered reasonable, we must have data indicating both the amount of information that can be derived from each sample of locations of a given size, and the expected cost. The "amount of information" in the above analysis is defined and measured in two ways. In Table 30 the "amount of information" refers to the percentage of reported information that could also be reported based on information derived from the sample of locations. In Table 24 the "amount of information" refers to the percentage of reportable type items that can be detected using various samples of locations. Each of these interpretations is used in turn in the following presentations.

Cost can be indicated either in terms of dollars and cents, or in terms of manhours of audit time used which can, in turn, be converted to dollars and cents. Since the governmental internal auditor normally schedules audits based on expected audit manhours to be consumed rather than on dollar estimates, costs are expressed in this analysis in terms of audit manhours consumed.

But how many manhours are used in a typical audit? The quickest reply one is likely to be given is that this question cannot be answered for there are no typical audits. Subject matter audits vary in the time required to develop an audit program, in the hours required to apply the program at each location, and in the number of locations at which the audit is accomplished. For planning purposes, however, audit managers during phase I of the research suggested the following number of hours:

Develop Program	Locations		Hours	Total
Initial Development	1	x	280	
Field Test Program	3	x	200	
Finalize Program	1	x	120	1,000
Establish Hours Per Location	1	x	200	
Determine Number of Locations	150	x	200	30,000
				31,000

Accepting these suggested hours, the cost of sampling curve originally hypothesized in Figure 2, page 11, can be constructed as shown in Figure 16, page 182.

The curve does not start at the axis intersection but at a point three percentage points up the scale due to fixed costs in the development of the audit program (1000 fixed cost hours divided by 31,000 total hours). Cost generated by application at each location is stable (200 hours per location), resulting in a steady rise in the cumulative cost of the subject matter audit through the final location, at which time 100 percent of costs are expended.

Sufficient data is now available to meet the objective of determining a range of locations for inclusion in each sample of audit locations selected from the possible universe of locations -- a range beyond which the incremental cost of information tends to exceed the value of the incremental information. To do so we need only to simultaneously graph both information and cost.

Figure 17, page 183, provides one view of this graphed data. The cost curve is drawn as previously described. The information curve is plotted using the average percentage of reported information available from sample sizes of five, ten, and fifteen locations as reported in Table 30. The curve is incomplete due to the

FIGURE 16

COST OF SAMPLING CURVE - PHASE III

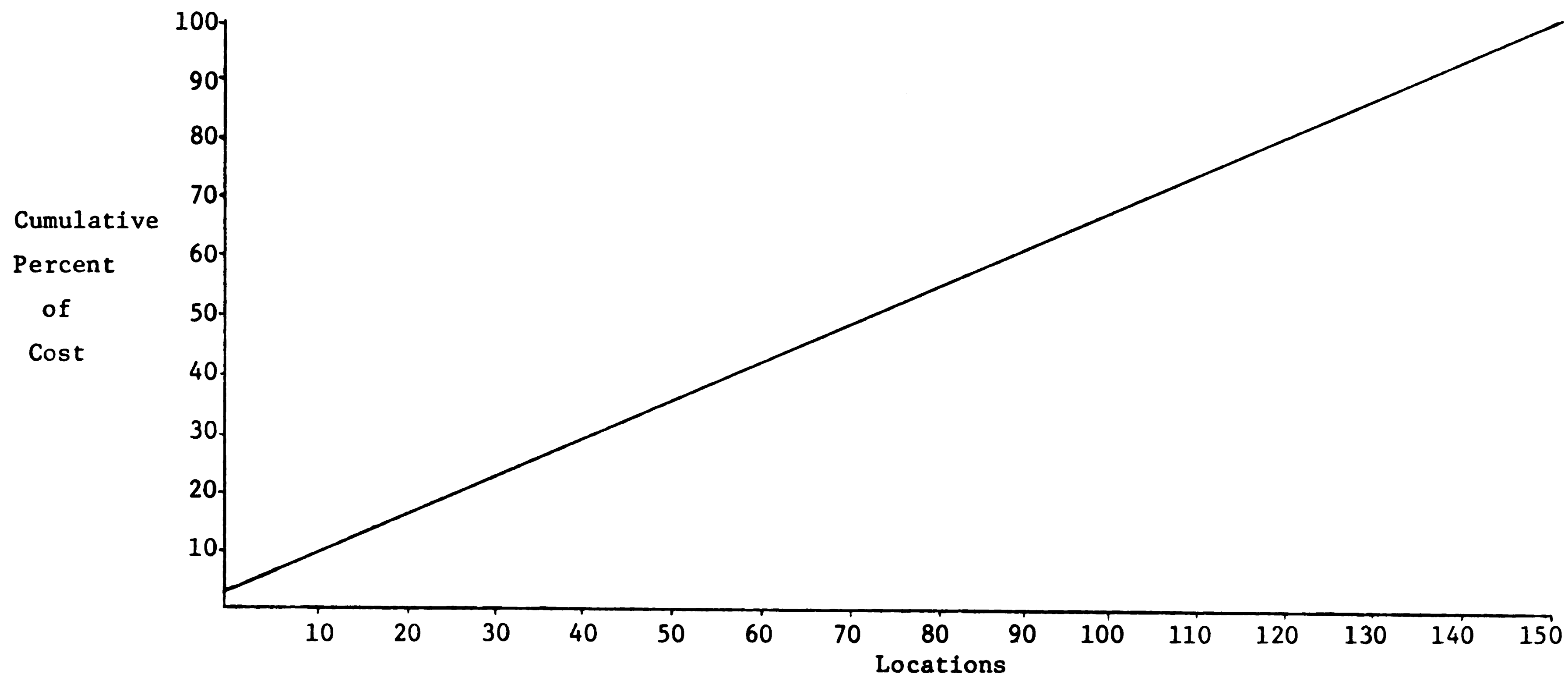
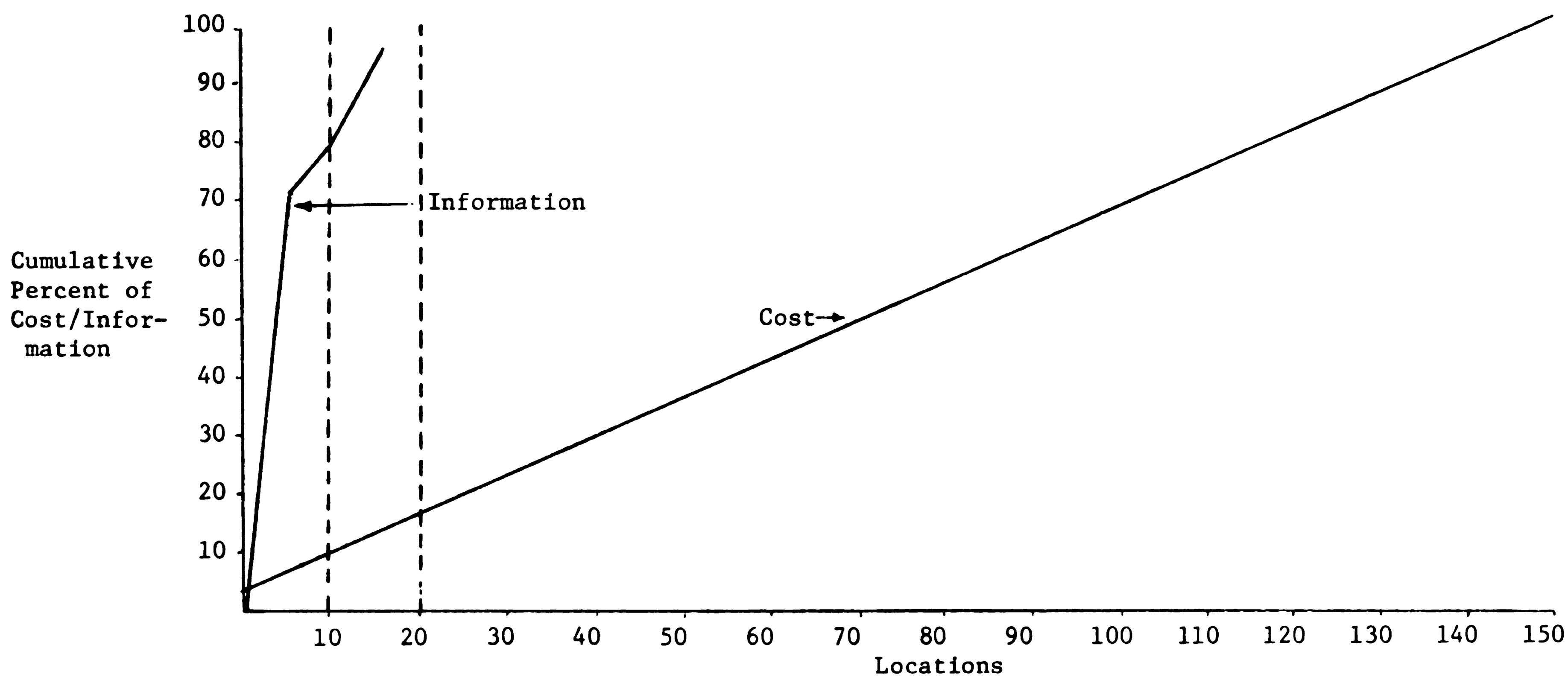


FIGURE 17

COST OF SAMPLING AND INFORMATION CURVE - I



limited scope of the sample sizes used in the research. The vertical dashed lines indicate visually a range of locations in which information appears to be maximized for the costs incurred.

Defining information as the detection of reportable type items provides a second view of the integrated data in Figure 18, page 185. Again, the cost curve is drawn as previously described. The information curve is plotted, however, using data shown in Table 31, page 186. Specifically, the information curve is constructed using the average cumulative percentages of Table 31 for a five, ten, and fifteen location sample. Note that Table 31 incorporates the research from both phase II and III. This curve is also incomplete due to the limited scope of the sample sizes used in the research. The vertical dashed lines indicate visually the same range of locations in which information appears to be maximized for the costs incurred.

Both figures indicate that the hypothesized "n" of Figure 3 (see page 12) lies in a range between ten and twenty locations. By the fifteenth location, on the average, 95 percent of the information that is recorded in the report of audit for the subject matter audit can be included in a report of audit based on the judgmentally selected sample. Also by the fifteenth location, 96

FIGURE 18

COST OF SAMPLING AND INFORMATION CURVE - II

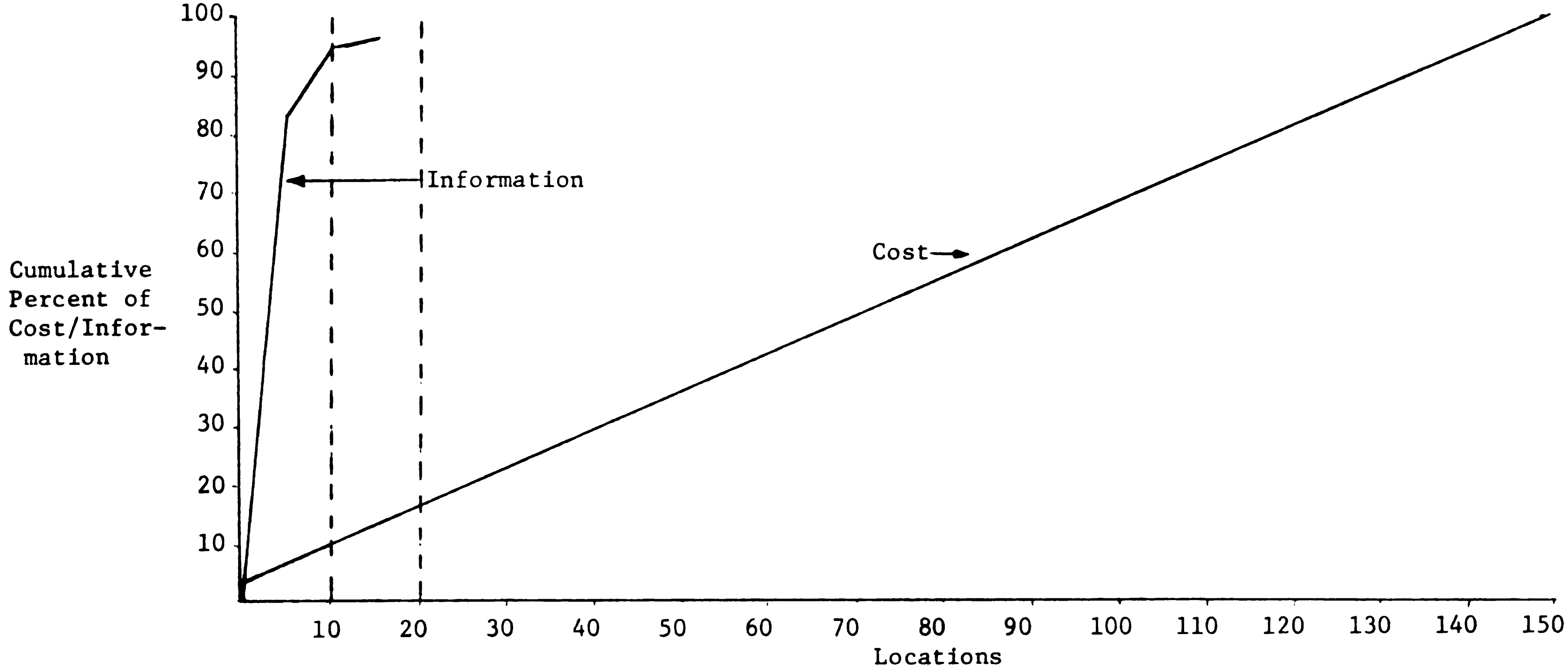


TABLE 31

CUMULATIVE PERCENTAGE OF REPORTABLE TYPE ITEMS FOUND - JUDGMENTAL METHOD
PHASE I AND II

Audit	Locations														
Code	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
AJ	27	40	47	56	71	80	80	80	84	87	89	89	89	91	91
BJ	41	56	63	69	75	84	94	94	97	97	97	97	97	97	97
CJ	51	57	63	80	86	89	94	94	94	94	95	97	97	97	97
DJ	38	53	60	69	71	76	80	84	89	93	96	96	96	98	98
EJ	30	47	63	70	70	80	83	83	93	93	93	93	93	93	93
FJ	34	59	76	83	83	95	98	98	98	98	98	98	98	98	98
GJ	30	60	60	70	70	70	70	80	90	90	90	90	100	100	100
HJ	17	67	67	67	67	67	83	100	100	100	100	100	100	100	100
IJ	33	100	100	100	100	100	100	100	100	100	100	100	100	100	100
A_2	41	63	80	88	92	92	92	94	94	94					
B_2	33	50	64	79	79	81	82	84	89	89					
C_2	37	47	60	75	84	88	91	92	95	96					
D_2	30	60	82	89	93	94	95	96	98	99					
Average	35	55	67	77	83	87	90	91	94	95	95	95	95	96	96

percent of the reportable type items for the subject matter audit can be detected. In other words, regardless of the way "information" is defined, on the average one can expect 95 percent or more of the information for, assuming 150 locations, just over 10 percent of the cost of a complete subject matter audit. To assure achievement of the remaining five percent of the information auditors must incur approximately 90 percent of the total audit cost -- clearly an uneconomical procedure. Again, more will be said about these data in the evaluation of research results presented in the following section.

An Evaluation of Results

Overview

As stated previously, one of the most important stages of a research project is evaluation of results. There the important question of what does it all mean is answered. The phase III research has been extensive as evidenced by the many tables of data and illustrative figures. The following evaluation of these data in brief discloses:

1. that when, as audit managers suggest, reportable type items are defined as operating errors or poor management practices that

occur at ten percent or more of the locations in the universe of locations, and when judgmentally selected samples of locations are used to detect these items, then the resulting information derived curves for each subject matter audit are similarly shaped.

2. that information derived curves developed using audit data generated at locations judgmentally selected as being representative of the population of locations are statistically superior beyond the hypothesized alpha level to those curves developed using audit data generated at locations randomly selected from the population of locations. Specifically, it was hypothesized that if one could expect on the average the information derived curves developed using audit data generated at locations judgmentally selected to lie above those curves developed using audit data generated at locations randomly selected 90 or more times in each 100 comparisons ($\alpha = .10$), then the curves developed from judgmental data would be considered statistically superior. For the nine subject matter audits analyzed in phase III of the research,

all nine judgmental curves are above the random curves. The computations on page 202 indicate that this result would occur only 19 times in 10,000 repetitions if either curve were truly likely to lie above the other. In other words, the computed result of .0019 is clearly significant beyond the .10 alpha level.

3. that general criteria can be developed to assist in the judgmental selection of locations for inclusion in each audit sample.
4. that approximately 95 percent of the reported management problems can be detected with sufficient materiality to warrant inclusion in a report of audit using judgmentally selected audit samples of fifteen locations.
5. that to maximize information for the costs incurred audit samples of from 10 to 20 locations are indicated. For audit samples in excess of this approximate range, incremental cost of audit tends to exceed the value of the incremental information.
6. that a table can be developed from the empirical research that will permit objective rather than the customary subjective decisions in the

management of internal audit resources. Specifically, consideration of data within the table suggests important new objective methods for determining management areas in need of audit attention, for handling the field test of new audit programs, and accomplishing what are here called "segmented audits".

These disclosures are developed in detail in the remaining portions of this section. Since each of these six disclosures is related to the six objectives specified for this phase of the research, the evaluation of data that follows is organized and presented under the objective to which it relates.

Objective One

The first objective of phase III of the research is to establish that when reportable type items are defined as operating errors or poor management practices that occur at ten percent or more of the locations in the universe of locations, and when judgmentally selected samples of locations are used to detect these items, then the resulting information derived curves for each subject matter audit are similarly shaped.

Recall that in phase II of the research audit managers were asked how many replications of the information derived curve constructed from judgmentally selected data would be required before they would be reasonably certain of its shape over a span of the first ten locations. Considering the research results of phase I, their professional opinion was that three or four additional curves would be sufficient. Accordingly, four additional curves were constructed.

The results of that research as recorded in Table 12, page 106 and in Figure 13, page 107 clearly indicate that the information derived curves for the subject matter audits selected for analysis are similarly shaped and that all the curves rise very rapidly over the first few locations included in the sample of locations. It was pointed out that the curves tend to level off between the fourth and fifth locations.

Although audit managers at the Air Force Audit Agency were satisfied that the shape of the information derived curve was reasonably determined, the phase III research serves to strengthen these conclusions.

Data for the judgmentally selected samples are contained in Tables 24 and 25, and in Figure 14 found on pages 164, 165, and 166 respectively. That the information derived curves constructed using data from phase II of the research are very similar to the information derived curves constructed using data from the nine subject matter audits of phase III of the research is evident from a comparison of the average percentages for these curves recorded in Table 18 and in Table 25. This comparison is as follows:

TABLE 32

AVERAGE CUMULATIVE PERCENTAGES
OF INFORMATION DERIVED CURVES
- PHASE II AND III -

Number of Locations	Research Phase (Table 18) II	(Table 25) III	(Table 31) II and III
1	35	36	35
2	55	54	55
3	72	63	67
4	83	72	77
5	87	76	83
6	89	83	87
7	90	87	90
8	92	89	91
9	94	92	94
10	95	94	95
11		95	95
12		95	95
13		95	95
14		96	96
15		96	96

The information derived curves rise very rapidly over the first few locations of the judgmentally selected sample. Looking at the line for ten locations, the phase III results indicate that one might reasonably expect to detect about 94 percent of all reportable type items while the phase II results indicate an average detection of about 95 percent of the items. The combined averages for phase II and III (see Table 31, page 186) bear the same characteristics as do the averages for phase II and phase III individually.

One may reasonably conclude that if audit managers are willing to accept the average percentages recorded in Table 18, then the percentages recorded in Table 25 that are based on data from more than twice the number of subject matter audits, or the data in Table 31 based on the results of both phases of the research should certainly be accepted.

Some question may be raised however, concerning the range between the best and worst percentages of reportable type items detected as the number of locations is expanded. Table 18, column 2 indicates that the known range of the percentage of management problems that can be detected using the selected number of locations in phase II of the research is very small. By comparing the best and worst percentage data recorded in Table 25, one can observe that the range is larger. It is important to the purpose here, however, to note that the larger range results from an extremely high "best percentage." The "average percentage" data for both phase II and III of the research are similar, and the "worst percentages" reported are very high reaching, for example, 87 cumulative percent by the tenth location. None the less, two questions should be explored in more detail. Of what importance is this observation to the research? Is there an explanation for these range differences?

The importance of the range is a function of the intended use of the information derived curves. This intended use is discussed briefly on pages 129-133 and will be elaborated upon in Chapters V-VII. Suffice it here to say that the curve is intended to provide audit managers with a method of making objective choices between quantity and cost of information. The curve is developed from an empirical examination of the types of audits normally accomplished and is proposed on the premise that similar management systems will be subject to future audit -- similar as to the scope of audit and as to the kind of information that will be of interest to top management.

To illustrate the importance of the range between the best and worst percentage of detection of reportable type items for a given sample of locations, consider the following example. Assume that an audit is to be field tested at seven locations. Table 18, page 122 indicates that, based on a past empirical review of results from similar audits, about 90 percent of the management problems of interest to top level management that are present in the universe of locations will be detected. The known range of such detection is no worse than 82 percent and has been as high as 95 percent. If the field test results do not indicate any management problems, one can reasonably conclude, even if only the worst past results are used as a guide, that an application of the subject matter audit to other locations would be fruitless. On the other hand, had the known range at seven locations been much broader, say from 1 percent to 99 percent, the decision to terminate the audit could not be made with as much confidence.

Is there an explanation for the larger range differences as evidenced by the data recorded in Table 25, page 165? More importantly, can this range be reduced? A careful review of the data suggests that one can answer yes to both questions.

The subject matter audits analyzed in each phase of the research have one criterion in common. Each audit is applied at a universe of 40 or more locations. This criterion, as stated before, is used for two reasons. First, to apply the research in subject matter audits that are most typical of the internal auditor's work. Within the Air Force subject matter audits are usually accomplished in management systems that are in use at 40 or more locations. And second, to demonstrate that the resulting information derived curves rise very rapidly over the first few judgmentally selected locations no matter how large the number of locations used in the audit.

Perhaps, however, an additional criterion should be used. Subject matter audits selected by audit managers for the first two phases of the research as representative of the internal auditors work meet not only the above criterion, but also apply to audits that produced 30 or more reportable type items. The number of reportable type items may reasonably be considered a function of the number of management areas to be reviewed, or stated another way, the number of audit steps the internal auditor must accomplish. The experienced audit manager will agree that usually subject matter audits are of sufficient scope to produce 30 or more reportable type items. Occasionally audit programs are developed to review a very limited number of management practices -- a number that could not result in at least 30 reportable type items -- but this is more exceptional than typical.

In phase III of the research, data for all nine subject matter audits that met the first criterion -- applied at a universe of 40 or more locations -- were analyzed. A review of data recorded in Table 23, page 163, discloses that six of these nine subject matter audits also met the additional criterion -- research applied in subject matter audits that produced 30 or more reportable type items. Three of the nine subject matter audits, however, did not produce at least 30 reportable type items. Specifically, audits GJ, HJ, and IJ produced 10, 6, and 9 reportable type items respectively. In each case these small numbers of items resulted from very limited audit programs.

That audit programs involving a very limited number of audit steps can radically influence the percentage ranges we seek to develop can be illustrated by the following example. Assume that a subject matter audit has but one reportable type item. If this item is not in evidence at the first location the percentage of detection is zero. If, however, the item is detected at the second location, the cumulative percentage would jump to 100 percent. By contrast, if the subject matter audit has 30 reportable type items, the detection of the first item will increase the cumulative percentage detection of reportable type items by only three percent.

By eliminating data for audits GJ, HJ, and IJ from those subject matter audits that are considered more normal in scope, and by combining the research results of both phase I and II, Table 33, page 199 is prepared. Like Table 18, page 122, Table 33 is a table for selecting the number of locations for audit when the objective is to detect management problems that occur at ten percent or more of the universe of locations. Note particularly that even though data for two and a half times the number of subject matter audits are used in the analysis, the known range of percentages reported in column 2 of Table 33 is very similar to the known range of percentages reported in column 2 of Table 18. Further, the averages reported in column 3 of each table are also very similar and exhibit the described characteristics of the information derived curves.

One can reasonably conclude that: (1) when interest is in what might be called the normal subject matter audit, one that is applied at 40 or more locations and will likely result in 30 or more reportable type items, and (2) when, as audit managers suggest, reportable type items are defined as operating errors or poor management practices that occur at ten percent or more of the locations in the

TABLE 33

TABLE FOR SELECTING THE NUMBER OF LOCATIONS FOR AUDIT
WHEN THE OBJECTIVE IS TO DETECT MANAGEMENT PROBLEMS
THAT OCCUR AT TEN PERCENT OR MORE OF ALL LOCATIONS
- PHASE I AND II RESEARCH -
- 30 OR MORE REPORTABLE TYPE ITEMS PER AUDIT -

(1) Number of Locations	(2) Known Range of the Percentage of Management Problems That Can Be Detected Using The Selected Number of Locations	(3) Average Percentage of Management Problems That Can Be Detected Using the Selected Number of Locations
1	27 - 51	35
2	40 - 63	54
3	47 - 82	68
4	56 - 89	77
5	70 - 93	83
6	76 - 95	88
7	80 - 98	90
8	80 - 98	91
9	84 - 98	94
10	87 - 99	95
11	89 - 99	95
12	89 - 99	95
13	89 - 99	95
14	91 - 99	96
15	91 - 99	96

universe of locations, and (3) when judgmentally selected samples of locations are used to detect these items, then the resulting information derived curves for each subject matter audit are similarly shaped.

These curves rise very rapidly over the first few locations, providing, for example, an average detection of 88 percent of all reportable type items through the fifth location included in the sample.

These findings as to the shape of the information derived curve have important implications for the management of Air Force internal audit resources. But before discussing these implications we must assure ourselves that the information derived curve constructed using judgmental methods for selecting audit locations is best suited to our purposes -- that it is superior to an information derived curve constructed using random methods for selecting audit locations.

Objective Two

The second objective of phase III of the research is to determine if there is a significant statistical difference between information derived curves developed using audit data generated at locations judgmentally selected as being representative of the population of locations, and those curves developed using audit data generated at locations randomly selected from the population of locations.

Although in the beginning it was hypothesized that curves constructed from judgmentally selected data would rise more rapidly and lie above curves constructed from randomly selected data, there was no knowledge of which curve, if either, would exhibit these characteristics. If either curve is equally likely to lie above the other, then the probability of one curve being higher than the other for each subject matter audit reviewed is .5. In this described situation one has the ingredients for a binomial experiment.

The experiment consists of nine trials or a review of the data for nine subject matter audits. Each trial results in one of two outcomes: the curve using the judgment method to select the data does or does not lie above the curve using random selection techniques. Since there is no prior knowledge of the frequency with which one curve lies above the other, one must assume that either curve is equally likely. The subject matter audits reviewed are independent and interest is in the number of times the curve using judgmental methods lies above the curve that uses the random selection techniques.

The formula for the probability distribution for the binomial experiment is:

$$p\ (y) = C_y^n\ p^y q^{n-y}$$

where: p = probability of success

y = the number of successes observed (one curve lies above the other)

n = number of trials (number of subject matter audits reviewed)

q = probability of failure

The data in Table 29, page 173, indicate that information derived curves constructed from judgmentally selected data lie above the curves constructed from randomly selected data for all nine subject matter audits. In terms of the formula above, this is equivalent to asking what is the probability that one specific curve will lie above the other in nine consecutive trials. The computations are as follows:

$$\begin{aligned} p\ (9) &= C_9^9\ (.5)^9\ (.5)^0 \\ &= \frac{9!}{9!}\ (.5)^9 \\ &= (.5)^9 \\ &= .0019 \end{aligned}$$

These computations indicate that if it is truly equally likely that one curve will lie above the other, then the result of the experiment would have occurred no more than 19 times in each 10,000 repetitions. In other words, it is very evident that information derived curves constructed using data judgmentally selected will lie above those curves constructed using randomly selected data.

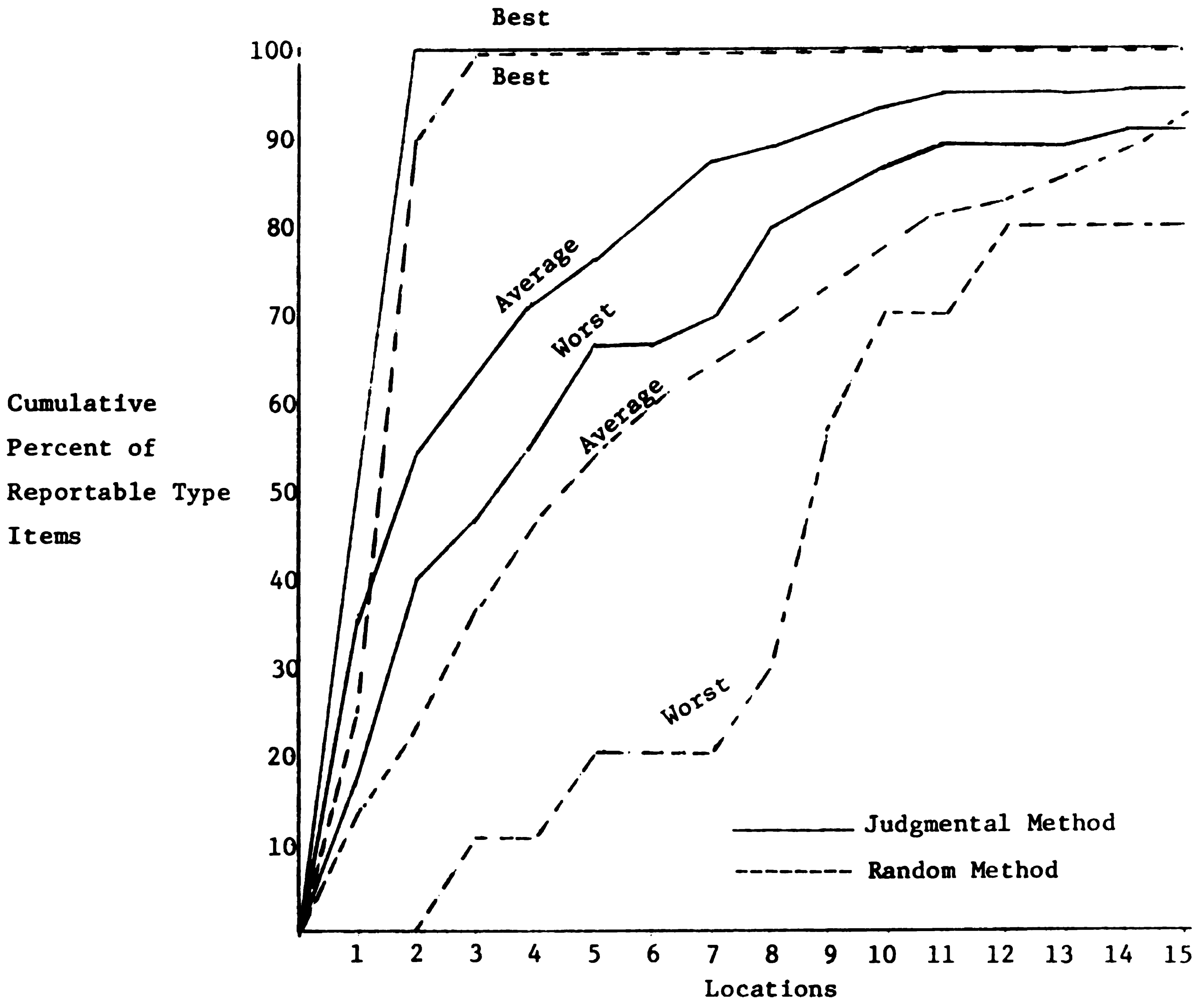
One criticism of the above method of showing statistical significance is that it does not make full use of all the data from each experiment. Specifically, data are used to indicate direction, that one curve lies above or below another, but data is not used that indicate the magnitude of the direction, how far one curve lies above the other. There are statistical methods for quantifying these differences. However, I believe that for the purposes sought by this research it is best to display these magnitudes visually.

Combining the composite information derived curves formed from the best, worst, and average percentage of data for the judgmental method of selecting locations for inclusion in each subject matter audit (Figure 14) with the composite information derived curves formed from the best, worst, and average percentage of data for the random method of selecting these locations (Figure 15) provides Figure 19, page 204. Note particularly that until the fifteenth location the average detection of reportable type items based on random methods of selecting audit locations lies below the worst percentages of detection of reportable type items based on judgmental methods of selecting audit locations.

Figure 19 utilizes the information curves of all

FIGURE 19

COMPOSITE INFORMATION DERIVED CURVES RESULTING
FROM BOTH JUDGMENTAL AND RANDOM SELECTION METHODS



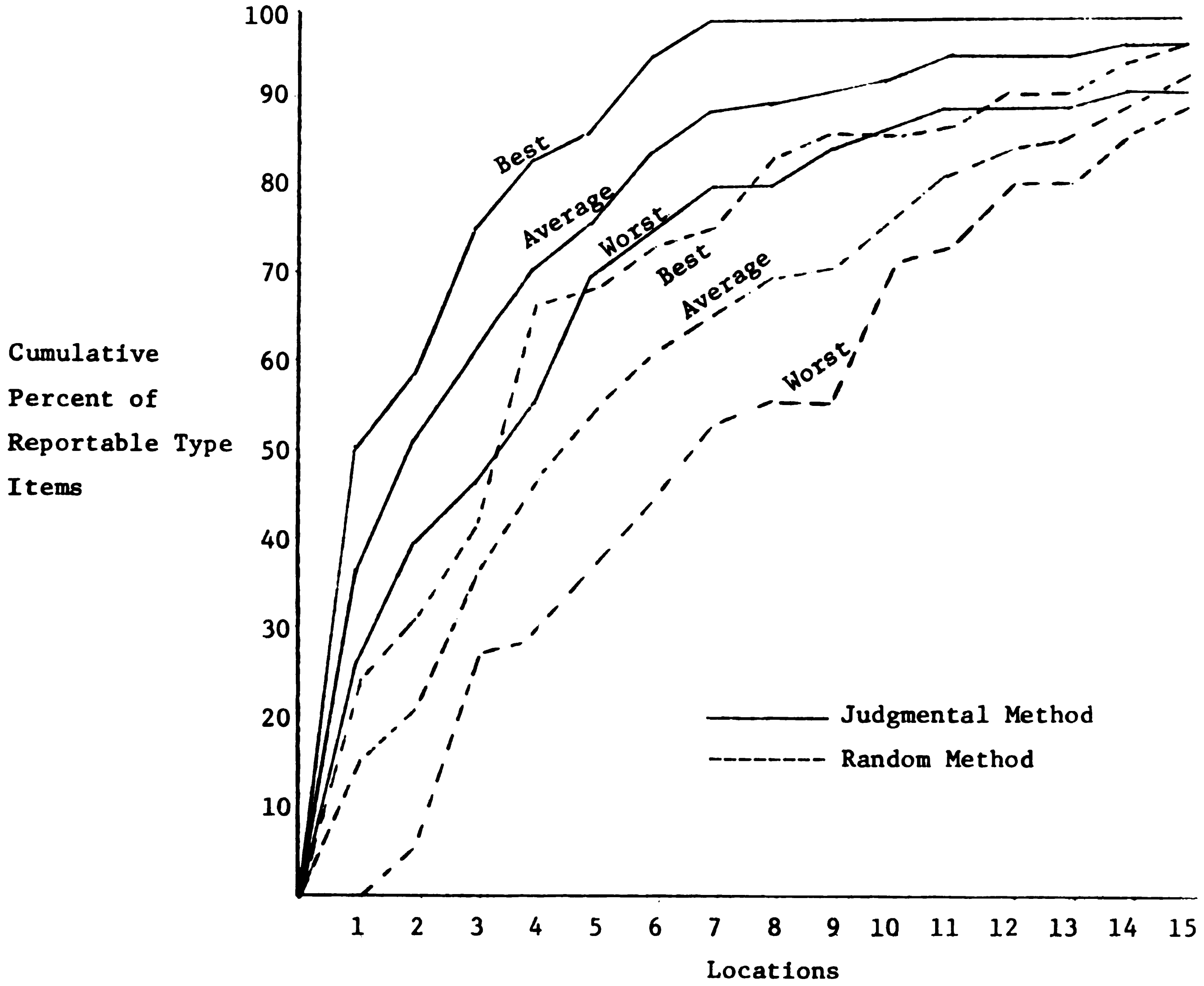
nine subject matter audits included in phase III of the research. When attention has been reduced to what have been called the six "normal" subject matter audits -- those that are both applied at 40 or more locations and will likely result in 30 or more reportable type items -- the differences between the curves become even sharper as shown in Figure 20, page 206. Note that the best results using random methods are very similar to the worst results using judgmental methods. And again, the average results using random methods are not as good as the worst results using judgmental methods until the fifteenth location is reached.

One can conclude that when the objective is to determine from a sample of 15 or less locations the reportable type items in the universe of locations, a greater percentage of these items will be detected when the locations are judgmentally selected. Worded in terms of the first objective, it has been demonstrated that an information derived curve constructed using judgmental methods for selecting audit locations is superior to an information derived curve constructed using random methods for selecting audit locations.

Accepting the superiority of the judgmental method one must now ask if we can do a good job in making judgmental selections of locations that will provide in the

FIGURE 20

COMPOSITE INFORMATION DERIVED CURVES
FOR THE SIX NORMAL AUDITS



future the same results observed in the empirical review of past records. Stated another way, can effective criteria be identified to guide these selections?

Objective Three

The third objective of phase III of the research is to identify criteria to select judgmentally audit locations from the universe of locations.

With regard to using a judgmental approach to select the sample, there is a central guiding criterion. The specific locations should be chosen in such a way as to provide information to top management which is representative of the total information system under audit. Criteria for selecting locations were identified by Air Force Audit Agency personnel and used by audit managers to select judgmentally each sample of locations for the nine subject matter audits analyzed.

It was hypothesized that if the selection criteria are appropriate and if they have been applied properly by audit managers, then information derived curves resulting from analyzing audit data from the locations in the order ranked will initially rise somewhat faster as additional locations are added to the sample of locations than will such curves resulting from analyzing audit data from these same locations but in the reverse order of their ranking, i.e. the fifteenth location becomes the first, the fourteenth becomes the second, and so on.

The data in Table 29, page 173, indicates that this is precisely the case. A comparison of the cumulative percentages over the first five locations for the "judgment" and "reverse" methods discloses that for all nine subject matter audits the judgment method, using the criteria identified by Air Force Audit Agency personnel, results in higher cumulative percentages. Over the first ten locations the "reverse" percentages rise above the "judgment" percentages for only one audit, audit D.

One can reasonably conclude that criteria can be and have been identified that provide the ability to select judgmentally and to rank locations according to their representativeness in the information system under audit. One cannot conclude that the criteria identified are the best or most useful to accomplish the objective, but they are at least minimally sufficient for effective choices to be made.

To this point in the analysis we have established the shape of the information derived curve and have discussed its characteristics. Judgmental methods have been demonstrated to be superior in the development of these curves, and criteria for accomplishing the judgmental selections have been identified. The next step is to show how use of this curve can result in more effective and efficient management of internal audit resources.

But before launching into such a discussion, let us digress and evaluate one other area of interest to the internal audit manager. Specifically, how much of the information that was contained in reports of audit could have been reported based on information derived from a sample of locations? And a closely related question, does the research indicate a sample range beyond which the incremental cost of audit tends to exceed the value of the incremental information? Turn now to the first of these two questions.

Objective Four

The fourth objective of phase III of the research is to extend knowledge concerning the percentage of information contained in the report of audit for the subject matter area that could have been reported based on information derived from judgmentally selected samples of five, ten, and fifteen locations.

The research, summarized in Table 30, page 178, indicates that for five, ten, and fifteen judgmentally selected samples, the average percent of information that one may reasonably be expected to report is 71, 80, and 95 percent respectively. The very cautious observer will note that the lowest percent that is reported from the data analyzed is a reasonably high 50 percent for a five location sample, 61 percent for a ten location sample, and 83 percent for a 15 location sample.

By contrast, if the locations are randomly rather than judgmentally selected, data recorded in the last four lines of Table 30 provide an indication of the probable quality of the result. For example, the percentage of reported information available from a fifteen location sample for audit AR is considerably less than the result that is achieved by a five location sample in audit AJ. The result achieved by a fifteen location sample for audit BR is matched by a ten location sample for audit BJ. The result achieved by a fifteen location sample for audit CR is no better than twenty five percent of the result achieved by a five location sample for audit CJ. Again, the cautious observer will note that the lowest percent that is reported for the four audits analyzed is a very low zero percent for a five location sample, twenty percent for a ten location sample, and twenty percent for a fifteen location sample.

These results should not be entirely unexpected. It has been pointed out that the rate at which reportable type items are detected using judgmental methods of selecting sample locations is consistently higher than the rate at which items are detected using random methods of selecting sample locations. Since these reportable type items can be expected to form the basis for the report of audit, one should normally expect a greater percentage of this reported information to be available from judgmentally selected samples.

The conclusion that can be reasonably drawn from these data is that if judgmental rather than random methods of selecting audit locations are used, a very high percentage of the reportable information is available from a small percentage of the universe of locations. Assuming a universe of 150 locations, about 95 percent of the reportable information is available from a sample composed of only 10 percent of all locations. This observation leads to the next objective.

Objective Five

The fifth objective of phase III of the research is to determine a range of sample locations beyond which the incremental cost of audit tends to exceed the value of the incremental information.

Figure 17, page 183, and Figure 18, page 185, both indicate that the hypothesized "n" of Figure 3, page 12, lies in a range between ten and twenty locations. As has been already observed, by the fifteenth location, on the average, 95 percent of the information that is recorded in the report of audit for the subject matter audit can be included in a report of audit based on the judgmentally selected sample. Also by the fifteenth location, 96 percent of the reportable type items for the subject matter audit can be detected. In other words, regardless of the way "information" is defined, on the average one can expect 95 percent or more of the information for (assuming a universe of 150 locations) just over 10 percent of the cost of a complete subject matter audit. To insure achievement of the remaining five percent of the information auditors must incur approximately 90 percent of the total audit cost -- an economically questionable procedure.

Following the limited research contained in phase I, the Air Force Audit Agency adopted one major change in audit method. The number of locations to be selected for certain planned subject matter audits was reduced to 60, about one-third of those previously included. It was stated at that time that this is only a step toward greater economical audit procedures. Research in more depth should provide more effective guidance for the selection of sample sizes.

The present research provides this guidance. Limiting subject matter audits to from ten to twenty judgmentally selected locations clearly meets the basic criteria of effectiveness and efficiency. The sample range is effective in that most of the information of interest to top management can be found, and it is efficient in that virtually the same report of audit is produced at reduced cost.

But the research provides more than this. If one can reasonably assume that the audit environment of the past several years is similar to the audit environment of today, then there is a reasonably objective method of quantifying audit decisions that have to now been made based on subjective judgments. For example, if a subject matter audit is planned in a management system that is in use at more than 40 locations, the tables provided in the research indicate that one can expect from a sample of fifteen judgmentally selected locations to include in the report of audit about 95 percent of the information that would be included if all locations were audited. If random methods are used to select the locations, an approximation of the loss of reportable type information can be made. If for some reason some level of management insists upon audit at the universe of locations and the audit agency is reluctant to comply, arguments can be phrased in terms of known incremental cost for the additional information provided.

In other words, it is my thesis that simply because auditors are involved in a management area that is not well suited to objective random statistical methods, this does not mean that purely subjective decisions are the only alternative. The decision variables can be quantified. Objective data can and are here provided to make these decisions, not with the exactitude of a precise mathematical model, but with the precision that objectivity can add to reason and experience.

Objective Six

The sixth and last objective of this phase of the research is to develop a table, based on an analysis of empirical data, that will provide audit managers a means of objectively determining the number of sample locations needed from a universe of locations to discover a specified portion of all reportable type items.

This objective is achieved by the construction of Table 33, page 199. To illustrate the use of the table, assume that audit managers decide to use a sample of seven locations. First locate the number seven under the first column of the table. Reading across, note that judgmentally selected samples of seven locations have in the past detected from 80 to 98 percent of all reportable type items. On the average, 90 percent of the reportable type items may reasonably be expected to be detected. Conversely, assume that one wishes to use a judgmental sample of all locations that can reasonably be expected to result in the detection of about 75 percent of all reportable type items. Reading down the third column of the table locate the percentage closest to this goal, in this case, 77 percent. Reading left across the row it is noted that a sample of four locations has a reasonable chance of providing this objective.

Although the table may be used directly or indirectly in a number of ways to assist in the management of internal audit resources, three uses will be discussed in the next three chapters. These uses relate to the determination of management areas in need of audit attention, to the management of field tests of new audit programs, and to the accomplishment of segmented audits.

These uses of the table are not mutually exclusive. That is, use of the table for one purpose may preclude the necessity of using the table for another purpose. For example, a method of audit management that uses the table in determining areas in need of audit attention could delete the necessity for a method of audit management that uses the table in managing field tests of new audit programs.

Each proposed method for managing internal audit resources will be discussed separately. It is for the interested reader to select the method or methods that will be the most useful.

The three proposed methods for managing internal audit resources are discussed in Chapters V-VII that follow -- discussions to which we now turn.

FOOTNOTES

1. This policy is reflected in the following reference: Air Force Audit Agency Regulation 23-6, Air Force Agency Organization and Functions, Norton Air Force Base, California, 1972, paragraph 5, page 40.

CHAPTER V

USE OF THE INFORMATION DERIVED CURVES IN DETERMINING MANAGEMENT AREAS IN NEED OF AUDIT ATTENTION

The purpose of this chapter is to demonstrate through reasonable argument that data provided by the information derived curves can be used objectively to determine management areas in need of audit attention. The chapter is organized into four sections. The first section elaborates upon the objectives sought. The second section provides background as to how management areas are selected for audit by the Air Force Audit Agency. In section three a hypothetical procedure for selecting audit areas is discussed. The chapter concludes with an evaluation of the proposal.

The Objective

As stated, the purpose of this chapter is to propose a method of determining management areas in need of audit attention. The primary instrument of this proposal is the information derived curve previously developed and summarized in Table 33, page 199.

Specifically, the objective is to demonstrate by reasonable argument that by using the data provided in Table 33, a method can be developed to determine objectively the extent of the management problems that will be commented upon in a subsequent subject matter audit <u>prior</u> to the full commitment of audit resources to the audit. A full commitment of audit resources is interpreted to extend from the audit manager's preparation of audit program through the completion of the resulting subject matter report of audit. The words "a method" rather than "the method" are purposely used because it is not my intention to suggest one method to the exclusion of others. Rather, the intention is to confine the discussion to an hypothetical example of a method that will suggest how the data produced by research in the previous chapters <u>can</u> be used, not how it should be used to manage internal audit resources within a multi-location organization such as the Air Force Audit Agency. A specific determination of how it should be used would involve a consideration of operating variables beyond the present scope of this research.

Background

Audit programs for subject matter audits within the Air Force Audit Agency are prepared centrally by specifically assigned audit managers.[1] The programs are written to review management functions at the various operating locations around the world. Each subject matter audit, from initiation of the audit program to release of the final report of audit, will consume thousands of audit hours and can require several months of the audit manager's time. To achieve economical utilization of audit resources it is vital that these resources be expended in management areas that will produce results attractive to top level management.

Management areas scheduled for coverage by a centrally directed subject matter audit are suggested by a variety of sources such as the Department of Defense, major commands, system managers, and the audit staff. All of these suggestions are well intended. Experience has shown, however, that sometimes subject matter audits completed as a result of these suggestions have not been as successful in detecting significant management weaknesses as was hoped. The fault may not lie with the audit manager nor with the application of the audit program, but with the decision process used to select that area for audit.

Decisions as to which management areas should be scheduled for audit have, in the past, been made primarily based upon subjective considerations. More recently, to provide some objective facts upon which to base these critical decisions, two procedures were used. The first procedure was called the Program Audit Development Survey. The second procedure is called the Directed Audit Research Task.[2] But as stated in an earlier discussion of these procedures (refer to pages 134-135) a measurement device, such as Table 33, was not used to indicate to audit managers the probable extent of the reportable type items that are detected by the sample of locations used. Consequently, audit managers must rely upon their subjective assessments of the need for audit within an area.

Hypothetical Procedure For Selecting Audit Areas

Using the results of the research provided in previous chapters as a management tool, the following hypothetical example and outlined procedure suggest one method for objectively determining the extent of management problems within an operating management system.

Assume that an audit of the XYZ activity is suggested. This activity will be in operation at nearly all of the locations to which Air Force internal auditors are deployed. Assume further, that due to the current internal audit workload, it will be about six months before an audit manager will be available to provide full attention to the project.[3] A review of the proposed objectives for the audit suggest that, if accomplished, one can reasonably expect 30 or more reportable type items to be detected.[4] Finally, assume that the audit is to be made in a management area for which a previous audit program has not been prepared. In other words, there are no "canned audit programs" on the shelf to suggest audit tests that should be made. This latter assumption will be relaxed later in the discussion.

Accepting these assumptions, the audit manager on whose schedule the subject matter audit is placed might take the following actions:

1. Identify at one of the Auditor General Resident offices an assigned internal auditor who is experienced in XYZ activity audits and capable of drafting a tentative audit program for this management area.
2. Prepare a letter identifying the audit objectives and requesting that the field auditor prepare a tentative program to review the management area. This letter should be drafted

several months before concentrated central programming work is scheduled to begin. The degree of detail contained in the letter could vary. For example, the audit manager who will eventually be responsible for the subject matter audit could spend from a few hours to several days clarifying the objectives, suggesting audit approaches, etc. Other than this, each letter should include information concerning:

a. The format of the draft audit program.

b. Time alloted the field auditor to develop the program.

c. The estimated number of hours that should be required for application of the finished audit program.

d. Processing instructions for the draft audit program.

3. Send the letter to the selected field auditor, requesting acknowledgment of the assignment.

4. Review the draft audit program when received, revise as necessary, and reproduce it in the desired number of copies.

5. Determine the number of locations at which the audit program will be used to review the XYZ activity. This number will depend upon the

percentage of reportable type items that the audit manager wishes to be reasonably certain of detecting. If the manager wishes 80 percent, for example, then Table 33 indicates that five representative locations should be selected. In the past, for this type of audit, five representative locations have been sufficient to detect an average of 83 percent of all reportable type items.

6. Identify the required number of locations, determined in step five, that are representative of the information system to be audited. These selections should be made based on criteria such as that outlined in Chapter IV, pages 153-154.

7. Send a copy of the audit program to the selected locations for application.

8. Receive from the selected locations the applied programs, supporting workpapers, local audit reports, and auditor critiques of the program. All of this packaged information should arrive prior to the date concentrated effort on the subject matter audit by the audit manager is scheduled to begin.

9. Review the advanced information on this activity being considered for a subject matter audit.

By following these steps the audit manager will know before resources are fully committed to the audit just where the actual management problems are and are not evidenced. He can, therefore, design the audit program for the subject matter audit so that it can provide the most information return for the audit hours expended. He will, in short, concentrate his efforts where audit need exists.

Returning to an earlier assumption, if there are usable "canned audit programs" on the shelf, then the steps necessary to make the objective assessments concerning the extent of management problems in a given area are, of course, reduced. Essentially, the fifth step could become the first step. The requirement to send a cover letter explaining the actions desired by the deployed auditor would replace step seven. But the resultant audit reviews should provide the same valuable information to audit managers.

An Evaluation

In this and the succeeding two chapters four basic criteria will be used to evaluate the hypothetical methods suggested. These criteria are: (1) provide the opportunity to assess the risk of not detecting reportable type items, (2) reduce the time required to achieve the subject matter report of audit, (3) reduce the cost in terms of audit hours, and (4) provide the same information to management as is provided by an audit accomplished at the universe of locations. Each of these evaluation criteria is considered in turn.

To facilitate discussion of the first criterion, Table 34, page 227 is prepared. The table is prepared using data recorded in Table 33, and therefore assumes the same type of audit. That is, the audit manager is interested in detecting management problems that occur at ten percent or more of the universe of locations and second, the audit is likely to produce 30 or more reportable type items. A rule of thumb way to judge this latter criterion is that the audit will require 100 or more hours to complete at each location.

Looking at Table 34, the first column indicates the number of representative locations included in the sample. Columns two, three, and four are labeled "risk preference". Column two is labeled a low risk preference. The percentages in this column are obtained by subtracting the lower limit of the range of percentages recorded in column two,

TABLE 34

TABLE FOR DETERMINING THE PERCENTAGE OF REPORTABLE TYPE ITEMS NOT DETECTED BY SAMPLES OF LOCATIONS FROM 1 TO 15

(1) Number of Locations	(2)	(3) Risk Preference	(4)
	Low	Average	High
1	73	65	49
2	60	46	37
3	53	32	18
4	44	23	11
5	30	17	7
6	24	12	5
7	20	10	2
8	20	9	2
9	16	6	2
10	13	5	1
11	11	5	1
12	11	5	1
13	11	5	1
14	9	4	1
15	9	4	1

Table 33, from 100 percent. For example, for a sample of one location, Table 33 indicates a low risk preference of 73 percent. This is obtained by subtracting the lower bound of the column two range for a one location sample found in Table 33 from 100 percent (ie. 100 - 27 = 73). The remaining percentages in column two, Table 34 are computed in the same manner. The average risk preference percentages recorded in column three are determined by subtracting the percentages recorded in column three, Table 33 from 100 percent. The high risk preference percentages recorded in column four, Table 34, are computed in the same manner as are the percentages recorded in column two except that the upper bound of column two, Table 33 is used rather than the lower bound.

Now let us consider how the data in Table 34 can be interpreted and used. The interpretation is straight forward. Consider a sample of five locations. The data indicate that from the empirical research, the worst result achieved by a sample of five locations from a subject matter area is a failure to detect 30 percent of the reportable type items present in the universe of locations. On the average, there is a failure to detect 17 percent of the reportable type items, while at best only 7 percent of the items are not detected.

The table may be used to determine how many representative locations should be included in a sample given the degree of risk the selector wishes to assume. If the selector has a low risk preference, that is the audit circumstances are such that he must detect at least a certain percentage of reportable type items with little or no margin for error, then the sample will be selected using data recorded in column two as a guide to the number of locations required. If the selector has a high risk preference, that is the audit circumstances are such that he feels very confident that if there are reportable type items at all they will be in evidence in the representative sample, then the data in column four will be used as a guide to the number of locations required. Finally, if the audit is to be accomplished under what may be called average or routine circumstances, the data in column three will be used.

It is not possible to specify which of the risk preferences should be used for that is a function of the characteristics of the audit situation and of the individual whose decision it is to determine the sample of locations. But regardless of which risk column is used, the importance of the table is that there is now some objective means of determining how many locations are "enough" given the degree of risk the audit manager is willing to assume. No longer is the audit manager entirely dependent upon his subjective judgments as to the number of locations needed. The table effectively organizes the results of past experience into a useful measurement tool -- a tool that can guide the audit manager in the economical selection of the results desired.

Now the reader may point out that all that has been done in Table 34 is to present the data of Table 33 in a different arrangement. In step five of the hypothetical example rather than use Table 33 as a guide in selecting the sample size, Table 34 could have been used just as easily. This is, of course, true. However, what is different is the approach to the interpretation of the data. While the same end result can be achieved regardless of the table used, our total understanding can at times be improved by looking at something from more than one angle.

One can conclude, however, that any hypothetical method that can make use of Table 34 to select the sample size can also meet the first criterion of the evaluation. That is, the opportunity to assess the risk of not detecting reportable type items is present.

Now consider the second of the four evaluation criteria -- reduce the time required to achieve the subject matter report of audit. By "time required" is meant the calendar number of work days extending from the date the audit manager devotes full attention to the project to the date the final subject matter report of audit is released.

The amount of time that may or may not be reduced through utilization of the hypothetical method will depend upon the planning and operating procedures followed by the audit organization. These procedures may vary between organizations and vary within the same organization for different audits. However, in general, one might expect the total time required to complete the subject matter audit will be reduced due to one or more of the following reasons:

1. The time required for the audit manager to prepare the audit program to be used will be reduced. This reduction in time may occur for one or both of two reasons. If a deployed auditor prepares a tentative audit program as suggested in steps one thru four of the hypothetical method, much of the research required to prepare the final program will already be accomplished. And second, even if a "canned audit program" is available for the initial review, the preliminary review of the area will determine those areas within the

subject matter audit that are in need of audit attention. Another way of stating this is to say that the preliminary review will determine those areas within the subject matter audit that are <u>not</u> in need of audit attention. Those areas can be deleted from the final audit program thereby reducing preparation time.

2. The time required to field test and revise the final audit program may be eliminated. Sufficient information from application of the tentative program may be available to delete the necessity of a field test and subsequent revision of the audit program.

3. The time required at each selected location to complete the audit program steps may be reduced. This follows from the expected reduction in the length of the program brought about by elimination of those portions of the proposed subject matter audit for which no reportable type items are detected by the initial review of the area.

For these same reasons one might reasonably expect a reduction in the overall cost of audit manhours used to produce the subject matter report of audit. The audit manager's time will be reduced due to the assistance received in the development of the audit program and, since the audit program will be restricted to known problem areas, less audit time will be expended at each participating location.

Finally turn to the fourth and last criterion. Does the hypothetical method provide the same information to management as is provided by an audit accomplished at the universe of locations? Answering this question brings out an interesting feature of the hypothetical model. There are trade-offs in the extent to which the criteria are met. As Table 34 indicates, one can be reasonably certain of detecting most all of the reportable type items only by using relatively large samples of locations and incurring the expense that that requires. On the other hand, one may accept a somewhat larger risk of not detecting some reportable type items in favor of a reduction in audit cost required for a larger sample. But once again, and this is important, we are able now to more objectively quantify these decision variables.

In summary, one can say that generally the first three criteria of the evaluation can be met. In doing so, however, the fourth criterion may not be met. The fourth criterion may be met, however, if we are willing to sacrifice at least some cost in doing so. But what is important to note is that the decision can be framed around reasonably quantifiable variables rather than purely subjective guess work.

FOOTNOTES

1. Air Force Audit Agency Regulation 23-6, Air Force Audit Agency Organization and Functions, Norton Air Force Base, California, 1972, page 31.

2. A description of the program Audit Development Survey was contained in Air Force Audit Regulation 175-101, Internal Audit Procedure, Norton Air Force Base, California, 1969, pp. 4-1 thru 4-2. A description of the Directed Audit Research Task is contained in Air Force Audit Regulation 175-105, Directed Audit Research Task, Norton Air Force Base, California, 1970.

3. This is a reasonable planning time within the Air Force Audit Agency.

4. Another reasonable way of determining this requirement is to state that the audit program will require 100 or more audit hours to complete at each location. The number of reportable type items are a function of the number of audit steps which are, in turn, a function of the number of audit hours allowed for the job at each location.

CHAPTER VI

USE OF THE INFORMATION DERIVED CURVES IN THE MANAGEMENT OF THE FIELD TEST OF NEW AUDIT PROGRAMS

A "field test" is a term that is applied to the procedure of trying out a newly developed audit program at a certain number of field locations. Audit programs centrally prepared by the Air Force Audit Agency are not always field tested prior to full scale use of the participating locations. But when they are, the research data proved in previous chapters can be used to improve management of these tests.

The purpose of this chapter is to describe how the research data can be used to improve management of the field test of centrally prepared audit programs developed to be used in the review of subject matter audit areas. The chapter is organized into three sections. The first section discusses the types of information the audit manager may seek from a field test of an audit program. There are basically two types: (1) information to assure that the proposed audit program can be understood and applied by the field auditor, and (2) information that will permit him to delete unproductive steps from the program. To illustrate how the research results may be used to obtain this second type of information, a hypothetical method is proposed in section two. The impact of the proposed method is indicated in section three where the proposed field test method is applied to data provided by the subject matter audits analyzed in phase II of the research. The chapter concludes with an evaluation of the proposal.

The Spectrum of Information Provided by a Field Test

The number of locations selected for the field test of a proposed audit program depends upon the information the audit manager for that subject matter area wishes to derive from the test. His needs may vary in a spectrum ranging from securing only enough information to assure that the proposed audit program as written can be understood and applied by the field auditor, to obtaining information that will allow him to delete those steps in the audit program that, if applied at the universe of locations, will not provide information of interest to top management.

The audit manager presently concentrates on his need in the lower end of this spectrum, that is, securing enough information to ensure finalization of a workable audit program. As a minimum, feedback concerning the following is sought:

1. The effectiveness of the tentative audit program in achieving audit objectives.
2. Suggested additions and deletions to the program.
3. Command problems that may be experienced in applying the program at certain locations.
4. The audit hours required to complete the program at each location.

Audit managers interviewed stated that a field test at one or two locations is usually sufficient to provide this information.

Each audit manager agreed that it would be helpful to move up the spectrum and to identify before hand those steps in the audit program that will and those steps that will not provide information of interest to top management if applied at the universe of locations. But they did not have a method to obtain such data.

A Hypothetical Method

Fortunately, these research data suggest such a method. Consider the following example that typifies the audit situation faced by the Air Force Audit Agency internal audit manager.

Assume that an audit manager is assigned the task of writing an audit program to review the "Z" system of management. The Z system has been in operation for a number of years at more than 40 locations around the world.

The audit manager is not certain of the degree of audit need in the various portions of the system. An audit program can be developed and applied to achieve a comprehensive coverage of all system areas, but this could result in much of the field auditor's work being spent in areas that produce no fruitful management information.

To avoid this situation, the audit manager must first decide what will be considered a fruitful finding to top management. In other words, how much audit "clean-up" of the system is desired? The auditor knows from experience that the most serious system weaknesses, for example those that occur at 80 or 90 percent of the locations, usually will evidence themselves at a one or two location sample. Those less serious conditions will require more locations in the field test to ensure their detection.

Assume, as has been done in this research, that the audit manager for the subject matter area that includes system Z believes management can best be served by bringing to light those management problems that occur at ten percent or more of the population of locations. This he believes represents a fairly comprehensive examination into the system and is in accord with management's needs.

He may now turn to the data contained in Tables 33 and 34 for assistance. To be reasonably certain that through the field test he will be able to identify 90 percent of the audit program steps that will result in the auditor's involvement with problems of interest to top management, he consults Table 33. There he notes that to achieve his objective a sample of seven judgmentally selected locations must be used in the field test. Table 34 indicates that with this sample size he runs a risk of not detecting as many as twenty percent of the audit program steps that will result in the desired type of information, but then again the detection rate could be much better than desired.

Assessing these possibilities and those provided by other sample sizes, the audit manager can decide just how the field test is to be managed. The final decision as to the number of locations to include in the field test will depend upon a balance between the degree the audit manager wants to be certain of detecting those audit steps that will review actual management problems, and the economics of administering a field test of the necessary size. But again, and this is repeatedly stressed, these decisions are made objectively based on past experience.

Following the field test, questions in the audit program are reviewed. Those questions that detect a management problem are identified. Auditors responsible for applying the audit program at other locations will use only those audit steps identified by the field test. The audit manager will use the field test results to delete those steps in the audit program that will not provide information of interest to top management.

An Application to the Research Data

If such a method had been followed for those subject matter audits analyzed in phase II of the research, Table 35 provides an indication of the extent portions of the audit program could have been deleted prior to the application at the universe of locations.

TABLE 35

RESULTS OF A SEVEN LOCATION FIELD TEST
OF THE AUDIT PROGRAM

(1) Audit Code	(2) Percentage of All Findings in Evidence (Table 8)	(3) Percentage of Reportable Type Items in Evidence (Table 12)	(4) Percentage not in Evidence in column (2)
A_2	76	92	24
B_2	36	82	64
C_2	78	91	22
D_2	82	95	18

Consider the data recorded for audit B_2. Column 2 indicates that 36 percent of all audit findings detected when the audit program was applied at the universe of 152 locations could have been in evidence at a seven location field test of the audit program. Column 3 indicates that included within those findings of column 2 are 82 percent of all information that will likely be of interest to top level management. Audit program steps that ultimately identified 64 percent of all total audit findings would have been completely unproductive in the field test.

Had a seven location field test been made of audit B_2 and acted upon as suggested above, a considerable portion of the audit program that was applied in its entirety at 152 locations would have been eliminated. Those eliminated portions of the audit program would include those audit steps that produced no information for any level of management plus those steps that produced results of interest only to managers at specific locations (that percentage recorded in Table 35, column 4). If this action had been taken, undoubtedly considerable savings in audit costs would have resulted.[1]

An Evaluation

Turn now to an evaluation of the field test method using the four criteria suggested in Chapter V. These criteria are: (1) provide the opportunity to assess the risk of not detecting reportable type items, (2) reduce the time required to achieve the subject matter report of audit, (3) reduce the cost in terms of audit hours, and (4) provide the same information to management as is provided by an audit accomplished at the universe of locations.

The first criterion is clearly met through use of Table 34 as described in the hypothetical method. Following the assessment of the risk of not detecting reportable type items, a final decision is made as to the number of locations to include in the field test. This number depends upon a balance between the degree the audit manager wants to be certain of detecting those audit steps that will review actual management problems, and the economics of administering a field test of the necessary size.

The second criterion -- reduce the time required to achieve the subject matter report of audit -- may or may not be met. This depends upon whether the audit program for the subject matter audit would normally be scheduled for a field test. If so, then a reduction in time can be expected, the extent of the reduction depending upon the audit time that would have been required to apply those unproductive portions of the audit program deleted following the field test. On the other hand, if the audit program is field tested for the specific purpose of refining the program, and if otherwise it would be used directly at the universe of locations, then the time required to achieve the subject matter report of audit obviously would be extended. Audit application at the universe of locations would be delayed until the field test is completed.

By using the field test method, cost in terms of audit hours would be reduced. Just how many hours would be saved for a given audit would be a function of the time that would have been required to apply the deleted portions of an audit program times the number of locations at which the refined audit program is applied.

Finally, one cannot state that the method will provide the same information to management as is provided by an audit accomplished at the universe of locations. But neither can it be said that it is desirable to do so. Again, as is discussed in Chapter V, there are trade-offs in the extent to which the various criteria are met.

As Tables 33 and 34 indicate, one can be reasonably certain of detecting most all of the reportable type items only by using relatively large samples of locations and incurring the expense that that requires. In terms of the present method, this means that to insure that a step in an audit program that will result in a reportable type item if applied at the universe of locations is not eliminated, a very large field test of the program must be made incurring the audit cost that that requires. On the other hand, one may accept a somewhat larger risk of eliminating certain audit program steps that will detect reportable type items in favor of a reduction in the cost required for the larger field test. Just what decision the audit manager will make will depend largely upon the quantifiable decision variables provided by the tables.

In summary, we can say that the first and third criteria should be met. Whether the second criterion is met is dependent upon whether the audit program for the subject matter audit is normally field tested prior to application at the universe of locations. If it is, then that criterion is also met. The extent to which the fourth criterion is met is a function of the cost the audit manager is willing to incur. But as in Chapter V, by using the research provided this decision can be reached considering reasonably quantifiable variables.

FOOTNOTES

1. Based on the research accomplished it is not possible to quantify this result. To do so requires three steps. First, all steps in the audit program that will be eliminated by the field test procedure must be identified. Second, the number of hours that would have been required to accomplish these deleted steps at each location must be determined. And finally, the hours required at each location must be multiplied by the total number of locations at which the refined audit program is applied. These computations must be made for each audit considered.

CHAPTER VII

THE SEGMENTED AUDIT

Methods discussed for determining areas in need of audit attention and for managing the field test of an audit program make specific use of Tables 33 and 34 developed from information derived curves. These curves were developed from judgmentally selected samples of the most representative locations for each subject matter audit included in the analysis.

Each location included in the sample is selected using criteria identified on pages 153-154. From working with audit managers who made the selections it was apparent that selecting and ranking the 15 locations required careful consideration of the merits of each location. For some of the subject matter audits 30 or more locations were considered by audit managers to have representative systems in operation. The problem was in the determination of the <u>most</u> representative.

Where these conditions exist one other method for the economical utilization of internal audit resources may be considered. The method is based upon the use of several "reasonably" representative samples for a given subject matter audit rather than upon the use of one most representative sample. Consequently, the data provided in Tables 33 and 34 developed from use of the most representative samples must be used as a guide only. Nevertheless, the method in the opinion of audit managers to whom it was explained, makes good sense and offers sufficient promise of greater economy in the use of audit resources to warrant its consideration.

The purpose of this chapter is to discuss this method called the segmented audit. Accordingly, the chapter is organized into four sections. The first section develops the background to the need for an audit method that will permit the review of a major portion of a management system without unduly infringing upon the audit hours controlled by the Resident Auditor. The segmented audit is defined and its use is illustrated by a hypothetical example. The chapter concludes with an evaluation of such audits.

Background

Each Auditor General Resident Office has a limited number of audit hours available for use. These hours must be used for both locally scheduled and centrally directed audit efforts. If too large a portion of these limited hours is expended on centrally directed audit efforts, the Resident Auditor is handicapped in providing needed information to the base commander.

Recognizing this fact, centrally directed audits are generally limited in scope. Most of these audits require from 100 to 200 audit hours at each selected location. Because of the present size of certain management activities such as base supply, base procurement, financial services, installation engineer and the like, this number of hours permits the analysis of only a small portion of each activity at any one time. Further, with the continuing integration of these activities through sophisticated electronic data processing equipment, the resulting systems are becoming even larger.

An auditing method is needed whereby the major portion of an activity or integrated system can be audited without unduly infringing upon the audit hours available to and managed by the Resident Auditor. If such a method can be developed, the audit organization will thereby be provided greater flexibility in its audit capability. One such method is through use of a segmented audit.

The Segmented Audit

A "segmented audit" is a term coined in this research that denotes a subject matter audit that is divided into parts. Each part is to be accomplished at a different sample of locations. The audit findings from each part are to be combined and summarized into a single report of audit. Such audits permit the same audit coverage with a smaller expenditure of local audit hours or an expanded audit coverage from the same expenditure of local audit hours.

To see how this might come about, let us explore a hypothetical example.

A Hypothetical Example

Accept for the moment the following simplifying assumptions. Assume that to review a major portion of a specified management system at any one location an auditor working alone would require 600 hours. At best, more than three months would be needed to complete the audit. Further assume that this system is in operation at 150 locations at which internal auditors are deployed. About one third of these locations are identified as being "reasonably" representative of the total management system. However, no attempt is made to rank order these 45 locations. There are several audit objectives identified for the audit, but each objective or combination of objectives can be accomplished independently of the audit data extracted in accomplishing another audit objective or objectives. The steps in the audit program used to accomplish these objectives can be conveniently divided into three parts, each part requiring 200 hours to complete. Finally assume that although the segmented audit is to be used, we want the resulting subject matter report of audit to provide top management about 95 percent of the information that would be provided if the complete audit program were applied at the universe of locations.

The mechanics of the segmented audit are now rather straight forward. First, a sample size must be selected. Using Table 33 as a guide, one may note that a sample of 10 or more locations will be needed to detect 95 percent of the reportable type items. To assure that these items are sufficiently material to warrant inclusion in a report of audit, Table 30, page 178 indicates that one must use a sample of 15 locations.

Accepting a sample size of 15 locations, the next step is to determine the possible number of segments into which the audit can be divided. This number is a function of the number of reasonably representative locations available and the number of independent sections into which the audit program may be divided. For the assumed conditions described, the audit may be divided into three segments (45 representative locations divided by the required sample size of 15) each requiring 200 hours (a 600 hour audit program divided into three independent parts of equal size) to accomplish.

Use of the segmented audit can result not only in a reduction in the number of locations participating in the subject matter audit (here 45 locations rather than the 150 in the universe), but in a substantial reduction in the number of audit hours consumed at each location as well (200 hours required for each segment while 600 hours are necessary for the complete audit program).

One can conclude that the report of audit will contain a very high percentage of the information of interest to top management at a considerable reduction in cost. However, as stated earlier, one must bear in mind that the amount of information contained in the report of audit will likely approach but not reach those percentages recorded in Table 30 for equal sample sizes since the samples used to abstract the information must be characterized as "reasonably representative" rather than "most representative".

Obviously, for a number of reasons, all subject matter audits are not appropriate for the segmented approach.

There may be an insufficient number of locations in the universe. There may not be enough representative locations. The audit program itself may not be suited for division. But when these conditions are met, a segmented audit approach can provide audit economy.

An Evaluation

Turn now to an evaluation of the segmented audit approach using the four criteria suggested in Chapter V. These criteria are: (1) provide the opportunity to assess the risk of not detecting reportable type items, (2) reduce the time required to achieve the subject matter report of audit, (3) reduce the cost in terms of audit hours, and (4) provide the same information to management as is provided by an audit accomplished at the universe of locations.

The first criterion, to assess the risk of not detecting reportable type items, is not as important to the segmented audit approach as it is to the methods described in the previous two chapters. It has been reasoned that the tables can be used as a general guide for determining sample sizes even though the data in the tables are based upon analysis of results from the most representative sample rather than from several representative samples from each subject matter audit.

Where the segmented audit can be used, it should result in a reduction of the time required to achieve the subject matter report of audit. This is obvious from the statistics used in the hypothetical example. It was stated that to review a major portion of a specified management system at any one location an auditor working alone would require 600 hours or more than three months to complete the audit. When the audit is segmented, however, the time needed is reduced to a third of that requirement, permitting the resulting information to be provided to top management at a much earlier date.

The third criterion, to reduce the cost in terms of total audit hours used for the subject matter audit may or may not be achieved. Again, using the statistics provided in the sample as an illustration, if the segmented approach had not been used and if the audit were applied at the universe of 150 locations, considerable audit hour savings would accrue. Specifically, only one tenth of the number of hours would be used by the segmented approach.[1] If the subject matter audit had been limited to 15 of the most representative locations in lieu of the segmented approach, then there would be no change in the total audit hours consumed. The audit burden at each selected location, however, would be considerably increased.[2]

The last criterion, to provide the same information as is provided by an audit accomplished at the universe of locations, is difficult to assess based on the research accomplished. Table 30 which has been used to determine the percentage of the reported information available from a sample is constructed using the most representative sample from each subject matter audit. One can only speculate that results achieved by representative rather than the representative sample will approximate these results. Verification, however, would require research beyond the scope of this investigation.

In summary, one can conclude that the method will clearly meet only one of the four criteria -- it will reduce the time required to achieve the subject matter report of audit. One cannot assess the extent to which the third criterion is or is not met without specific data concerning the number of audit locations to be included in the subject matter audit. Assessment of the remaining two criteria cannot be made without additional research that is beyond the scope of this investigation.

Nevertheless, the segmented audit makes good sense and offers sufficient promise of greater economy in the use of audit resources to warrant further research, and probably to warrant its consideration even without research.

FOOTNOTES

1. The equivalent sample of 15 locations would be used from the universe of 150 locations. Specifically, 45 locations using 200 audit hours at each location is equivalent to 15 locations using 600 audit hours at each location.

2. If the audit program is applied at 15 selected locations, 600 audit hours will be required to complete the audit program at each location. The segmented approach as described will require only 200 audit hours at each location.

CHAPTER VIII

CONCLUSION

This study proposes new considerations specifically for the management of United States Air Force internal audit resources. As previously stated, over the past several years the need to find more efficient internal audit methods has become increasingly serious. DOD internal audit staffs have been reduced relative to the size of the internal audit workload. This pattern of a diminishing auditor staff concurrent with an expanding internal audit workload has become a matter of serious concern. In the three years ended June 30, 1971, Air Force Audit Agency personnel authorizations declined approximately 22 percent and there is no reason to expect a reversal in this trend. During this same period Air Force resources grew both in cumulative inventory and annual consumption. There has been no significant reduction in the number of major locations at which the Air Force operates.

The proposals contained in this study are advanced in the belief that they can provide some of the answers to the increasingly complex problem of managing internal audit resources. At the heart of these proposals are four basic hypotheses identified in Chapter I. These hypotheses are in brief:

1. The information derived curve is shaped as illustrated in Figure 1, page 10.
2. Information derived curves developed from judgmental selection of individual audit locations are superior to such curves developed from random selection of individual audit locations.
3. There is a minimum number or at least a range of locations for a given audit for which audit cost can be considered reasonable.
4. The information derived curve can provide an internal audit management tool, the use of which can result in more efficient use of internal audit resources.

The purpose of this concluding chapter is to review each of these hypotheses in the light of the research results achieved.

Hypothesis One

The first hypothesis is that the information derived curve is shaped as illustrated in Figure 1, page 10. That is, the first few locations in a judgmentally selected sample of locations can make relatively large contributions to the total amount of information that is derived from the subject matter audit. As the number of locations included in the sample increases, the total amount of information derived may increase, but at a decreasing rate.

All three phases of the research were designed to test this hypothesis. Each phase used a slightly different approach. For the first phase "information" was defined as data about operating errors or poor management practices that were observed to occur in the field of audit observations at a rate of ten percent or more. Three representative subject matter audits were selected by audit managers for analysis. For each subject matter audit, audit managers judgmentally selected samples of 10, 20, 30, and 60 locations. The rate at which information was generated by these samples of locations for each subject matter audit was determined. These results are recorded in Table 3, page 68, and illustrated in Figure 10, page 69. It is apparent from these data that most of the information is provided by samples of only 10 locations. However, the phase I research was not sufficiently detailed to determine the specific rate at which this information is accumulated.

For phase II of the research the general term "information" was replaced by a more carefully defined "reportable type item". Reportable type items were defined in three separate ways to test the effect of changes in the definition on the resulting shape of the information derived curve. The definition that audit managers believed would encompass those types of problems of interest to top level managers is as follows. The operating error or poor management practice occurs at ten percent or more of the locations in the universe of locations. Four representative subject matter audits were selected by audit managers for analysis. For each subject matter audit, audit managers judgmentally selected samples of 10 locations. The rate at which reportable type items were generated by these samples of locations for each subject matter audit was determined. The most meaningful of these results are recorded in Tables 11 and 12 and in Figure 13, pages 105-107. It is apparent from these data that the information derived curve rises very rapidly over the first few locations included in each sample. Specifically, the average detection of reportable type items by only the fifth location is more than 80 percent. Doubling the sample size to ten locations results in an average detection of reportable type items of 95 percent, a small gain for a 100 percent increase in effort.

Phase III of the research was designed to remove doubt as to the general shape of the information derived curve from the most skeptical of observers. For this phase of the research reportable type items were defined as operating errors or poor management practices that occurred at ten percent or more of the locations in the universe of locations. All nine subject matter audits in the files of the Air Force Audit Agency were selected for analysis. For each subject matter audit, audit managers judgmentally selected samples of 15 locations. Again, the rate at which reportable type items were generated by these samples of locations for each subject matter audit was determined. The most meaningful of these results are recorded in Tables 23 and 24, pages 163-164, and in Figure 14, page 166. It is apparent from these data that results are very similar to those achieved in phase II.

The results of phase II and III that apply to normal subject matter audits -- those that should involve 30 or more reportable type items -- were combined to provide the data listed in column 3, Table 33, page 199. These combined results indicate that the information derived curve rises very rapidly over the first few locations included in each sample. Specifically, as is the case for the results of phase II and III individually, the average detection of reportable type items by the fifth location is over 80 percent. Doubling the sample size to ten locations again results in an average detection of reportable type items of 95 percent.

One can conclude that the research results strongly confirm the first hypothesis.

Hypothesis Two

The second hypothesis is that the information derived curves developed from a judgmental selection of individual audit locations are significantly superior to such curves developed from a random selection of individual audit locations.

Phase III of the research was designed to test this hypothesis. The data in Table 29, page 173, indicate that for all nine subject matter audits, information derived curves constructed using judgmentally selected locations lie above those constructed using randomly selected locations. Through use of the statistical formula for the binomial experiment it was indicated that the curves constructed using judgmentally selected locations are clearly statistically superior. Indeed, as Figure 20, page 206 shows, the best results achieved by randomly selecting the locations were no better than the worst results achieved by judgmentally selecting the locations. These differences were particularly evident over the first ten locations included in each sample. By the fifteenth location the differences persisted, but were less severe.

Based upon these research results one can again conclude that the second hypothesis is confirmed.

Hypothesis Three

The third hypothesis is that there is a minimum number or at least a range of locations for a given audit for which audit cost can be considered reasonable. Beyond that range the incremental cost of audit tends to exceed the value of the incremental information.

Phase I and III of the research examined this hypothesis. Phase I of the research provided the results shown in Table 3 and Figure 10, pages 68-69. The research was not sufficiently detailed to pinpoint the desired range, however it was very clear that less than a population of locations should be included in each subject matter audit. Following disclosure of these results, the number of locations selected for certain planned subject matter audits by the Air Force Audit Agency was reduced by a third.

In phase III of the research cost of sampling was introduced. Considering both of the variables of information and cost, the research results indicated that the information return for the costs incurred was maximized over an approximate range of from 10 to 20 audit locations. This result is indicated in Figure 17, page 183. By the fifteenth location, on the average, 95 percent of the information that was recorded in the report of audit for the subject matter audit could be included in a report of audit based on the judgmentally selected sample. This information could be achieved from a sample that will consume only about 10 percent of the audit costs required for a complete subject matter audit. To assure achievement of the remaining five percent of the information auditors must incur approximately 90 percent of the total audit cost -- clearly an uneconomical procedure.

Based upon these research results one can conclude that there is a range of locations for a given audit for which audit cost can be considered reasonable.

Hypothesis Four

The fourth and last hypothesis is that the information derived curve can provide an internal audit management tool, the use of which can result in more efficient use of internal audit resources.

The confirmation of this hypothesis was the primary purpose of the presentations provided in Chapters V-VII. Chapter V discussed the use of the information derived curves in determining management areas in need of audit attention. Chapter VI followed with a discussion of the use of the curves in the management of the field test of new audit programs. Finally, Chapter VII concluded with a discussion of a proposed technique called the segmented audit.

Summary

In summary, all four of the hypothesis specified at the outset of the research are reasonably confirmed by the research results. It follows then that the proposals for improving the management of internal audit resources within the Air Force Audit Agency or of any other multilocation organization operating under similar conditions have merit and should be carefully considered.

Like a lawyer, however, the researcher can only present his case supported by the evidence of his research and strengthened by the reasonableness of his arguments. But it is management who in the final analysis sits in judgment of the fate of his ideas and suggestions. My evidence is presented. The arguments are made. My case rests.

LIST OF REFERENCES

Books

Anthony, Robert N. Planning and Control Systems: A Framework For Analysis. Cambridge, Massachusetts: Harvard University Press, 1965.

Argyris, Chris. Integrating the Individual and the Organization. New York, London, Sydney: John Wiley & Sons, Inc., 1966.

Arkin, Herbert. Handbook of Sampling for Auditing and Accounting. New York, San Francisco, Toronto, London: McGraw-Hill, Inc., 1963.

Barnard, Chester I. The Functions of the Executive. Cambridge, Massachusetts: Harvard University Press, 1970.

Cadmus, Bradford, Operational Auditing Handbook. New York, N.Y., The Institute of Internal Auditors, 1964.

Conover, W. J. Practical Nonparametric Statistics. New York, London, Sydney, Toronto: John Wiley & Sons, Inc., 1971.

Hendriksen, Eldon S. Accounting Theory. Homewood, Illinois: Richard D. Irwin, Inc., 1970.

Koontz, Harold and O'Donnell, Cyril. Principles of Management. New York, New York: McGraw-Hill Book Company, 1968.

March, James G. and Simon, Herbert A. Organizations. New York, London: John Wiley & Sons, Inc., 1959.

Mautz, R. K. and Sharaf, H. A. The Philosophy of Auditing. Chicago, Illinois: American Accounting Association, 1961.

Mendenhall, William. Introduction to Probability and Statistics. Belmont, California: Wadsworth Publishing Company, Inc., 1968.

Mendenhall, William. The Design and Analysis of Experiments. Belmont, California: Wadsworth Publishing Company, Inc., 1968.

Willingham, J. J. and Carmichael, D. R. Auditing Concepts and Methods. New York, New York: McGraw-Hill Book Company, 1971.

Articles and Periodicals

American Accounting Association. "Committee on Accounting Concepts and Standards, 1957 Revision," The Accounting Review, October 1957.

Coupland, Don. "Current Management -- An Audit Challenge," The Armed Forces Comptroller, April 1967.

Kane, M. "A Clarification of the Broadened Role of Internal Auditing," The Internal Auditor, Spring 1961.

Kusel, Jimie. "Man-On-The Spot," The Armed Forces Comptroller, April 1969.

Sparrow, H. G. "Mission-Oriented Audits," The Armed Forces Comptroller, Vol. 12, No. 2, April 1967.

Sternberg, Alexander J. "What Management Should Expect of the Internal Auditor," The U. S. Army Audit Agency Bulletin, December 1965.

Walsh, Francis J., Jr. "Trends in Audit Management," The U. S. Army Audit Agency Bulletin, December 1965.

Official Documents

Air Force Audit Agency Regulation 11-5, Processing Summary Reports of Audit, Norton Air Force Base, California: Department of the Air Force, 1 March 1972.

Air Force Audit Agency Regulation 23-3, Areas and Activities of the Air Force Audit Agency, Norton Air Force Base, California: Department of the Air Force, 31 July 1972.

Air Force Audit Agency Regulation 23-6, Air Force Audit Agency Organization and Functions, Norton Air Force Base, California: Department of the Air Force, 31 July 1972.

Air Force Audit Agency Regulation 175-101, Internal Audit Procedures, Norton Air Force Base, California: Department of the Air Force, 1 March 1969.

Air Force Audit Agency Regulation 175-105, Directed Audit Research Task, Norton Air Force Base, California: Department of the Air Force, 21 September 1970.

Air Force Audit Agency Regulation 175-112, Initiating and Controlling Centrally Directed Audits, Norton Air Force Base, California: Department of the Air Force, 1 August 1972.

Air Force Audit Agency Regulation 175-116, Statistical Sampling for Auditors, Norton Air Force Base, California: Department of the Air Force, 17 July 1972.

Air Force Audit Agency Regulation 175-118, Statistical Sampling, Norton Air Force Base, California: Department of the Air Force, 14 September 1971.

Air Force Regulation 175-4, Auditing in the Air Force, Washington, D.C.: Department of the Air Force, 15 June 1972.

Department of Defense Instruction No. 7600.1, Summary Report of Audit Operations. Washington, D.C.: Department of Defense, 16 July 1971.

Department of Defense Directive No. 7600.2, Department of Defense Audit Policies. Washington, D.C.: Department of Defense, 19 August 1965.

Department of Defense Instruction No. 7600.3, Internal Audit in the Department of Defense, Washington, D.C.: Department of Defense, 25 May 1968.