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A STUDY OF AUDITOR DATA PROCESSING KNOWLEDGE REQUIREMENTS FOR COMPUTER BASED MANAGEMENT INFORMATION SYSTEMS

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ABSTRACT

A STUDY OF AUDITOR DATA PROCESSING KNOWLEDGE REQUIREMENTS FOR COMPUTER-BASED MANAGEMENT INFORMATION SYSTEMS

Technological advances in computer systems, cost reduction of processing data, and increased vulnerability of computers mandate that internal and external auditors possess the data processing (DP) expertise necessary to audit these systems to assist business management and to protect the public interest.

The purpose of this study is to define the data processing knowledge requirements of internal and external auditors. A three-phased Delphi survey was used to establish these requirements. Expert internal and external auditors participated in the survey using an open-ended questionnaire, a current technology installation model, and an appropriate audit scope (IIA or AICPA) to make their judgments. Phase III survey results were used to construct internal, external, and composite auditor DP knowledge profiles. Seven accredited five-year accounting programs were evaluated on the basis of the composite profile.

Four major findings resulted from the research: (1) the systems analysis area was the most important area of DP knowledge required by internal auditors. The DP operations, DP management, audit techniques, and software areas were rated as important. Computer hardware was the least important. (2) The DP operations, DP management, software, and the systems analysis were rated as important DP knowledge required by external auditors. The computer hardware and audit techniques areas were rated as moderately important. (3) The DP knowledge requirements of internal auditors are generally higher than the knowledge requirements for external auditors. Major areas of difference were systems analysis and audit techniques. (4) The present required courses of the selected five-year accounting programs do not meet the DP knowledge requirements of auditors. Only three schools had the complete program necessary to meet the DP knowledge requirements.

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ACKNOWLEDGEMENTS

A study of this nature requires the cooperation and assistance of a large number of people and organizations to bring to a successful completion. The writer is deeply indebted to each one of them.

A special thanks is due to my committee for their kind support and encouragement. Professor Frederick C. Kurtz ably served as committee chairman and provided critical early support. Dr. Marvin M. Wofsey deserves especial tribute for his expert and thorough review of the dissertation. I am indebted to Dr. Ernest H. Forman for accepting committee responsibility during the proposal stage, and for his constructive criticism. It was gratifying to have a man of Dr. Robert V. Head's stature to take time to serve as an outside committee member, contributing positive criticism with computer acumen. I was fortunate to have mr. Guy M. Piper II of Price Waterhouse as the second outside committee member. His experience in the subject area was especially helpful.

A heartfelt thanks to the academicians who reviewed the survey instrument and the twenty-nine internal and external auditors who carefully considered all 295 survey questions three separate times. Their names and the names of their firms are listed in Appendices A, C, and D. Thanks also to the accounting schools for providing information on their curricula.

I would be remiss if I did not express my appreciation to Miami University for the financial support and to my colleagues for their encouragement. Dr. George F. Williams especially gave advice and practical assistance.

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CHAPTER I

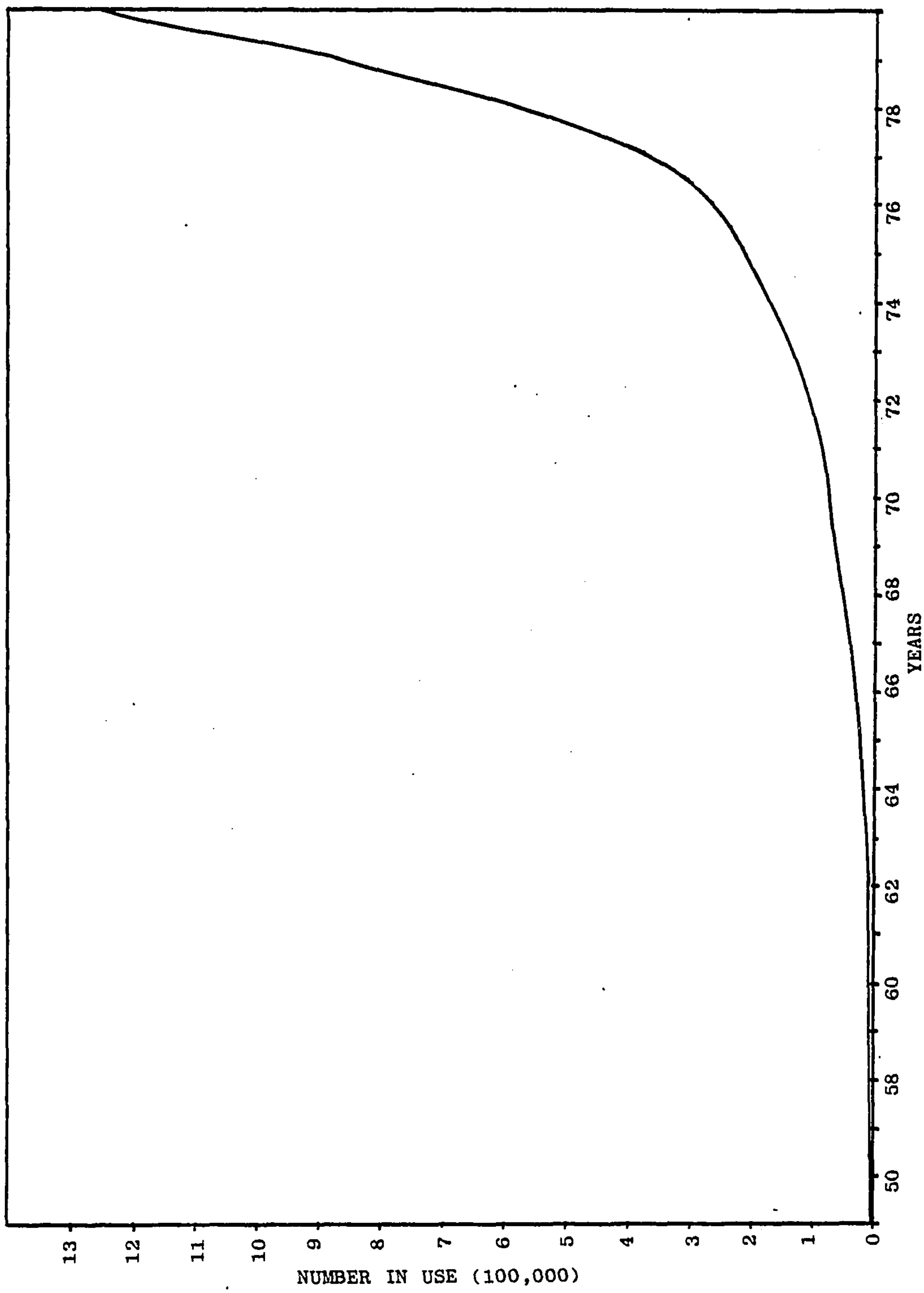
INTRODUCTION

Definition of the Problem Area

In advanced industrial nations, accurate, timely, and reliable information is crucial to the smooth operation of society. Large and complex organizations are commonplace and characterized by management activities that are far removed from the numerous locations where the information is generated, recorded, summarized, and reported. Since the effectiveness of decisions depends in large part on the integrity of support information, management has found it beneficial to use auditors to provide an independent assessment of the accuracy and reliability of the information. In cases of public ownership, the government has found it to be in the public interest to have an independent assessment of the information. Auditors must have an understanding of how this information is generated, manipulated, stored, accessed, summarized, and reported in order to have the basis for providing reasonable assurances that the information is accurate and reliable. This knowledge is particularly important within the United States because of the rapidly growing computer base that ranges from very small to highly sophisticated computer systems. The end result will be that auditors who do not understand computers will be experts for manual management systems--few of which will exist.

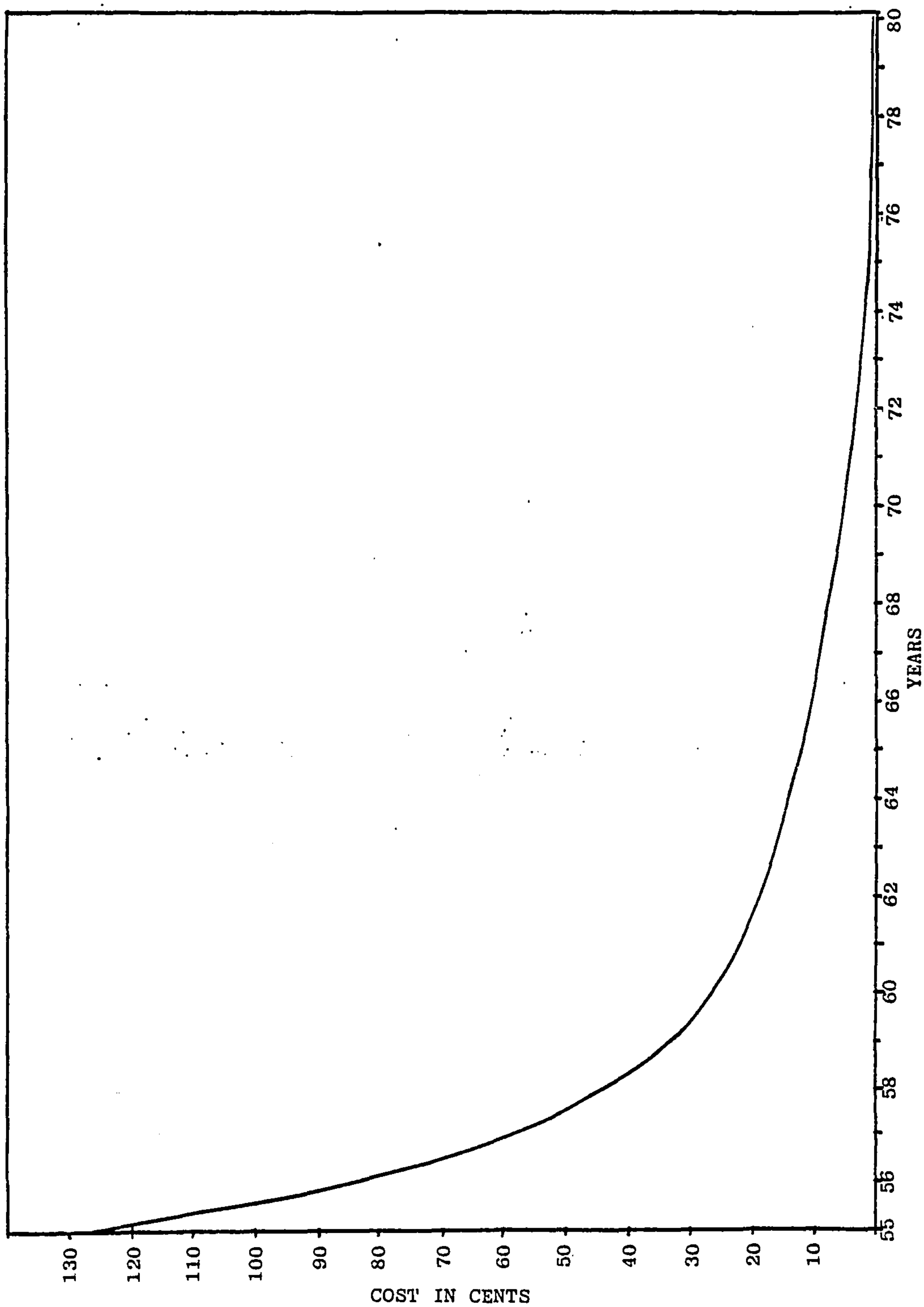
The Computer Environment

Since the introduction of the first commercial computer in 1951, there have been unprecedented steady advances in computer technology. Technology has increased the processing speed, data storage, and processing capacity of computer systems by a factor of over one hundred and there is no expectation that this rate of increase will diminish (1). This steady increase in technology has been accompanied with a steady decrease in the cost to store and process data. The inevitable result has been that computers have become economically irresistible and often crucial to the survival of the business. One result of these events has been a dramatic increase in the number of computer systems in use. Fig. 1 graphically illustrates this growth in the number of computers in use and Fig. 2 illustrates the reduction in processing cost. Since the technology and cost trends are expected to continue into the foreseeable future, the use of computers can reasonably



SOURCE: IDC and Montgomery Phister

Fig. 1. Commercial Computer Use Growth



SOURCE: Montgomery Phister

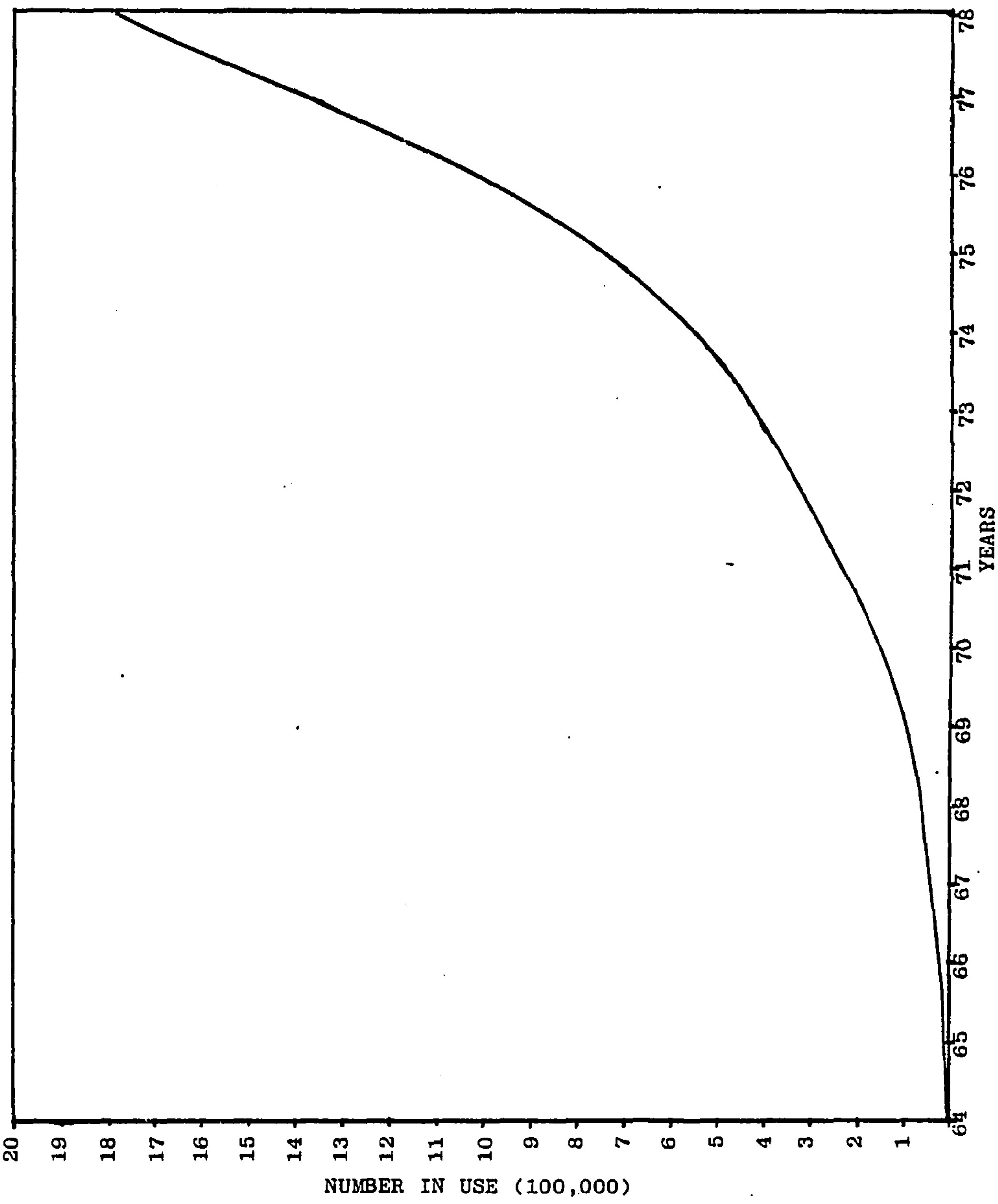
Fig. 2. Cost of Computation

be expected to continue to increase at the projected rate. The four aspects of these events that are relevant to this study are the growing prevalence of computers, their increasing capability, the increasing complexity of their exploitation, and the increasing vulnerability of businesses using them.

The growth in the number of computers by itself is persuasive evidence that societal problems concerning computer use should be dealt with in a timely manner. However, the aspect of increasing computer complexity is equally compelling. During the first thirty years hardware manufacturers and software vendors have primarily focused their attention on improving the efficiency and economy of their products. The result has been progressively more efficient, powerful, and complex computer systems which have required the introduction of several new data processing specialties. To illustrate this increased complexity--early computer installations consisted of a single, centrally located processor that had one job stream. Computer processing consisted of job input, processing, and output for one job at a time. Where they existed, computer operating systems were generally limited to the orderly processing of the job stream. The processing was accomplished at centralized sites and the computers could only be accessed from the centralized sites (2).

Current technology computers commonly have several current and/or simultaneous job streams. The operating systems have evolved into a sophisticated set of programs capable of operating the computer system with little human intervention. The processing units and data files are often located and operated from one or more locations geographically separated from the centralized computer site. Frequently these dispersed computers are connected through a communications network which permits access from a wide variety of terminal devices which can be located anywhere there are telephone lines. The degree to which businesses have taken advantage of this advanced technology is evidenced by the growth in the number of these remote terminal devices in use. Fig. 3 illustrates this growth in the use of remote terminal devices.

The importance to this study of the increases in numbers and complexity of computers lies in the increased dependence of the businesses using these systems. Gibson and Nolan and others have suggested that businesses go through a series of identifiable growth stages once they have acquired a computer (3). While their stage hypothesis has not been proven, there is little question that businesses do expand their computer systems both in size and complexity as they gain computer experience. The expansion



SOURCE: Montgomery Phister

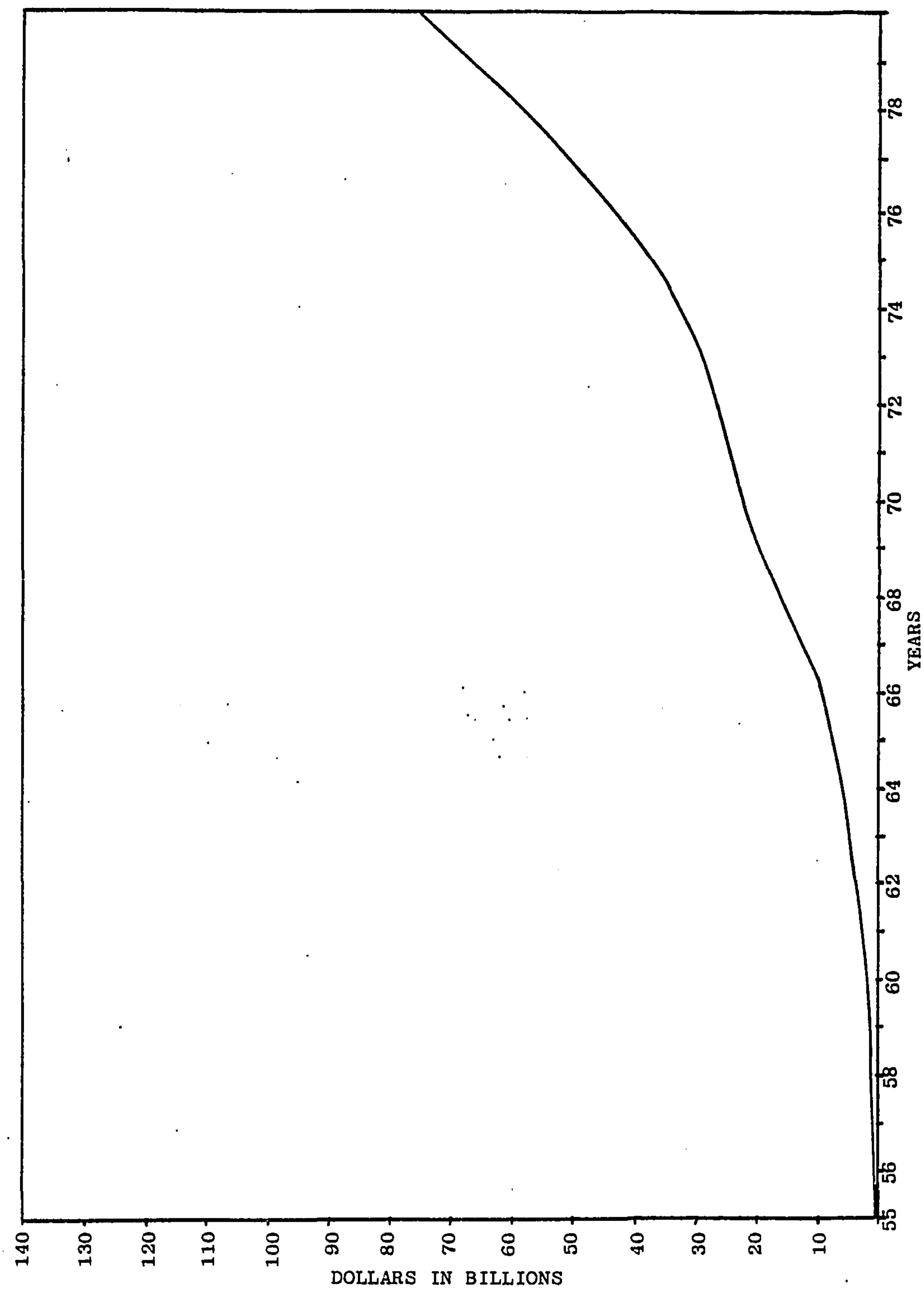
Fig. 3. Number of Computer Terminals Installed

is no doubt economically motivated as the result of more responsive data processing, higher information accuracy, and improved profitability. This expansion has frequently advanced to the extent that daily operations are dependent upon the computer. A few cases can be cited where loss of computer files resulted in the inability of the business to survive. Bill Smiley, of the Toronto computer consulting firm of Hutchinson Smiley Limited, said:

> The DP center is becoming the heart of the company. Everything goes through it. Most companies will last two weeks without the computer center. After five weeks, there is no recovery. (4)

Fig. 4 illustrates this increasing dependence in terms of the rising computer hardware investment.

It has been within only the last few years that much attention has been given by manufacturers and business management to the increasing vulnerability of computer systems and their users. The vulnerability results in large part from the computerizing of key business and control functions, the high concentration of information, the elimination of traditional separation of duties, the use of electronic versus hard copy records, and the creation of a new highly skilled group of people potentially able to subvert the system without detection. This vulnerability became public knowledge in the early 1970s with the disclosure of a series of computer frauds. The two billion



SOURCE: Montgomery Phister

Fig. 4. Dollar Value of Investment in Computer Hardware

dollar Equity Funding case is often credited with providing the visibility needed to reorient the myopic view of manufacturers and business management to include better computer hardware, software and management controls. The Pacific Telephone case is also important, since it provided clear evidence that computer vulnerability was not the private domain of a company's management and employees. These events established beyond reasonable doubt that resources managed by computer are potentially vulnerable to unauthorized manipulation from any terminal device that can gain access to the system. The FBI was quoted in Digital Design as estimating that only one percent of computer crimes is detected and of these only twelve percent are reported. A 1973 study found that only one out of five subjects referred to the courts received a sentence imposing confinement. The odds of going to jail were only one to thirty three, for those receiving a sentence imposing confinement. The FBI also reported that the average non-computer fraud was approximately $23,500 and the average computer fraud was about $621,000 (5). It should be kept in mind that these figures are based upon known, reported frauds which were perpetrated using relatively simple schemes. Parker, Allen, Stone, and Alderman have collectively reviewed several hundred computer fraud cases and observed that the known frauds were so simple that it caused them to wonder what unknown, complex, fraudulent schemes the really smart people were using (6).

The Audit Environment

There is usually a lag of several years between the introduction of new technology and man's ability to exploit it. This has been true in the area of business' use of computer and it is true of the audit profession's ability to audit computer based management information systems effectively. Studies have shown that the problem of effectively auditing electronic data processing (EDP) systems is shared by internal and external auditors. The problem does not lend itself to a quick solution due to the rapid change of large bodies of knowledge in both accounting and data processing. Both fields have several specialties where the specialists find it difficult to maintain currency because of the acceleration of developments. These problems are being cautiously addressed by the major auditing organizations.

The Institute of Internal Auditors (IIA) and the American Institute of Certified Public Accountants (AICPA) are the predominant internal and external auditing membership organizations. Under an IBM grant, the IIA sponsored a Stanford Research Institute study on Systems Auditability &

Control (SAC). The SAC study found that many auditors were auditing computer based systems as if the computer did not exist. The SAC study also found existing audit techniques to be inadequate for auditing state of the art computer systems. Finally, the study identified the need for auditors to attend fundamental and advanced data processing courses when they were charged with the responsibility of auditing computer based systems (7). Another key internal audit study was conducted by Paul Macchiaverna of The Conference Board. The Macchiaverna study results are consistent with the SAC study, but in addition, the study found that businesses frequently recruit data processing professionals for their EDP audit organizations in order to improve their audit capability for computer based management information systems (8). Neither of the studies identified the data processing knowledge requirements for internal auditors, but left no question that internal auditors need substantially more knowledge than they currently have. Finally, for those internal auditors employed by companies subject to the Securities Exchange Act of 1934, the Foreign Corrupt Practices Act of 1977 created additional accounting system requirements that must be addressed by auditors in system development and operational audits (9).

The role and responsibilities of internal auditors vary considerably from that of external auditors. Internal auditors are established within an organization to perform an independent appraisal function. They maintain their independence by avoiding any functional management responsibility. According to the Macchiaverna report, the original primary function of most internal auditing units was to serve as a psychological deterrent against wrongdoing; that is, preventing the misappropriation of company assets. With the broadening of audit scope, the internal auditors began emphasizing their positive contributions, such as helping the business become more efficient and more effective (10). They examine and evaluate other organizational activities as a service to members of that organization (11). The major computer frauds, the Foreign Corrupt Practices Act, and SEC actions to increase management and auditor liability, have caused internal auditors to rethink their responsibilities and take a stronger stance against fraud (12). The internal audit standards state that:

> In exercising due professional care, internal auditors should be alert to the possibility of intentional wrongdoing, errors and omissions, inefficiency, waste, ineffectiveness and conflicts of interest. They should also be alert to those conditions and activities where irregularities are most likely to occur. In addition, they should identify inadequate controls and recommend improvements to promote compliance with acceptable procedures and practices. Due care implies reasonable

> care and competence, not infallibility or extraordinary performance. Due care requires the auditor to conduct examinations and verifications to a reasonable extent, but does not require detailed audits of all transactions. Accordingly, the internal auditor cannot give absolute assurance that noncompliance or irregularities do not exist. Nevertheless, the possibility of material irregularities or noncompliance should be considered whenever the internal auditor undertakes an internal auditing assignment. (13)

As a matter of law, external auditors are members of a private, profit oriented business whose ownership is independent of the business being audited. The primary external audit function is derived from the SEC and the Federal security laws. Congress enacted the securities laws to protect the public and to provide accurate information on publicly owned corporations. The SEC was given wide authority to determine accounting standards, procedures, and forms for publicly owned corporations. In 1938, the Commission, by a margin of one, voted to rely on the private standards-setting bodies (14). As a result the Auditing Standards Board (ASB) promulgates generally accepted auditing standards and the external audit firms audit those publicly owned firms regulated by the Securities Act. The role and function of the external auditor is to examine the financial statements of these firms and express an opinion as to the fairness with which they present the financial position, results of operation, and changes in financial position in conformity with the generally accepted accounting principles. External auditors are not responsible for detecting even material fraud if they have complied with generally accepted auditing standards (15). It is noteworthy that the AICPA established Commission on Auditors' Responsibilities has recommended a change to the ASB and AICPA stance on fraud. Their report recommends that an audit be designed to provide reasonable assurance that the financial statements are not affected by material fraud. They further recommend that the auditor search for material fraud (16). The requirement to search for material fraud has been incorporated into section 327 of the *Professional Auditing Standards*. Several studies have been made of computer fraud cases with respect to compliance with generally accepted auditing standards, but none could be identified that addressed auditor data processing knowledge requirements.

The AICPA has not published guidance on the data processing knowledge requirements of external auditors. They have provided a framework for approaching an EDP audit in sections 110, 320, and 321 of the *Professional Auditing Standards*. According to a footnote, the framework will be used for the development of further guidance concerning auditing procedures in examining financial statements of entities that use EDP in accounting applications. Two articles have appeared in the Journal of Accountancy on data processing proficiency. Both articles recognized the need for data processing knowledge, suggesting that three levels in the context of an audit team would be appropriate. The three levels were "deemed necessary because of the great variety of EDP equipment, software, and processing techniques in existence today and the rapidity of technological change in the field" (17). Special requirements were not identified.

A third major audit group was formed in 1972 in recognition of the growing need for more competent EDP auditors. This group, the EDP Auditors Association (EDPAA), is composed of internal and external auditors and sees its role as complementary to the IIA and AICPA. Its primary objective is to assist its membership to attain a high degree of education and experience in addressing EDP system control problems and developing methods and techniques to eliminate them. In 1976 they formed the EDP Auditors Foundation for Education and Research to establish a forum for greater recognition and emphasis on EDP audit education and research. In 1978 they established an EDP auditor certification program to identify those individuals who meet minimum EDP audit qualifications. They are in the process of developing the EDP audit body of knowledge and preparing their certification program.

The Problem

The rapid growth in the numbers, complexity, and vulnerability of computers in use, along with a corresponding increase in the dependency of the organizations using them, has been established. The writer also discusses the increasing problem of computer fraud and the limited ability of auditors to discourage or detect fraud. The literature frequently addresses the problem of audit techniques which lag computer technology and the application of this technology in computer based management information systems. Research concerning computer crime has been directed primarily at audit technique versus the impact on the level of DP knowledge required of auditors. No minimum levels of data processing knowledge have been identified for internal or external auditors. Additional research is required to define auditor data processing knowledge better with respect to the scope and responsibility of internal and external auditors and current computer technology. Further, the professional education programs need to be reviewed to determine if the identified levels of data processing knowledge are reflected in the curricula in order to prepare auditors adequately for entry into the profession.

Purpose of the Study

The purpose of this study was to define further the data processing knowledge requirements for auditors charged with auditing current technology computer based management information systems. The study was based on a three phase Delphi survey of selected internal and external audit experts qualified in auditing and data processing. An open-ended questionnaire was constructed based on the literature review, discussions with experts in the field, a review of eight selected computer fraud cases, and the education and experience of the researcher. The EDP audit experts then determined the relative importance of the various data processing knowledge areas, using the three-phase Delphi process. Data processing knowledge profiles were then prepared for internal auditors, external auditors, and a composite profile of both internal and external auditors. An analysis was conducted to determine if there was a significant difference between the two groups and the identity and magnitude of the differences. The profiles were then compared to eight selected five year accounting programs. Conclusions were drawn as to the adequacy of the program in terms of the data processing knowledge requirements established by the experts. Recommendations were made concerning areas needing further research.

The Research Questions

Earlier discussion identified the need to define the data processing knowledge requirements of internal and external auditors. Also of interest was the impact of the increasing governmental regulation of the private sector. Over the years, the Federal and state governments have established a clear trend of imposing management requirements through the passage of legislation, particularly in the areas of securities, equal rights, privacy, and corporate corrupt practices. With the exception of the securities area, the audit burden has quite often fallen into the domain of the internal auditor due to the differences in the internal and external audit roles. These events could increase the relative data processing knowledge requirements of internal versus external auditors. A series of exploratory research questions were developed to guide the research and analysis. The questions were as follows:

Major Question

What are the data processing knowledge requirements of internal and external auditors?

Subsidiary Questions

1. What data processing knowledge is required by

internal auditors to audit current technology computer systems?

2. What data processing knowledge is required by external auditors to audit current technology computer systems?

3. What are the differences in data processing knowledge required by internal and external auditors?

4. Do the curricula of the selected five year accounting programs recognize the data processing knowledge requirements of: (a) internal auditors? (b) external auditors?

Study Limitations

1. The study addressed only internal and external data processing knowledge requirements with respect to current technology computer systems.

2. The study addressed internal and external auditor data processing knowledge requirements with respect to the audit standards promulgated by the IIA and the AICPA. The study did not address any additional data processing knowledge required to provide management advisory services.

Study Assumptions

1. Internal and external auditing are professions

with required bodies of knowledge.

2. Data processing knowledge is a part of the internal and external auditing body of knowledge.

3. The individuals establishing the knowledge requirements must be competent in terms of the body of knowledge and the application of that knowledge within the profession.

Contribution of the Study

The study of the data processing knowledge requirements of auditors is pertinent and timely. Further, it is an important area within which original research can make a contribution to the existing body of knowledge. Major current studies have been conducted in the internal and external audit fields that have highlighted the need for improvement in the area. Earlier studies have addressed parts of the auditor data processing knowledge requirements for the external auditor. There remained a need for a more pervasive research approach which emphasized the vulnerabilities of current technology systems and provided a more precise definition of data processing requirements. The comparative evaluation of the knowledge requirements against selected five year accounting programs was timely since they are in the formulative stage. Finally, the need and timeliness of the study are evidenced by the interest of the major audit organizations and internal and external audit professionals. They are actively concerned with the area and striving for improvement. It is believed that the study made contributions in the following areas:

1. It addressed both internal and external auditor data processing knowledge requirements individually and in a comparative context.

2. It introduced the use of a hypothesized current technology computer installation characteristics to standardize and assure currency of the data processing knowledge determinations of respondents.

3. It provided the first comprehensive data processing knowledge requirements profile for internal auditors charged with the responsibility for auditing current technology computer systems.

4. It provided a more current and comprehensive data processing knowledge requirements profile for external auditors charged with the responsibility for auditing current technology computer systems.

5. It provided an early evaluation of five year accounting programs with respect to the data processing knowledge requirements of internal and external auditors.

6. It was the first application of the Delphi research methodology to establish professional knowledge requirements.

The study results should be useful for several different purposes. These include use in preparing certification examinations, accounting education programs, auditor continuing education, and for further research. The relevance of the study was evidenced by the interest and assistance provided by the IIA, AICPA, EDPAA, the Financial Executives Institute (FEI), and the Canadian Institute of Chartered Accountants (CICA).

Organization of the Study

This dissertation is organized to provide the reader with a logical development of the study. Chapter I introduced the study with brief discussions of the computer and audit settings. The chapter then provided a discussion of the study purpose, the research questions, and the expected contributions. Chapter II will provide a review of the literature relating to computer and auditing developments, auditing techniques, and auditor data processing knowledge requirements. The discussion in Chapters I and II will establish the background information required for the reader to evaluate the appropriateness of the research and the timeliness of the study. Chapter III will provide a discussion of the study methodology. The following chapters provide an analysis of the results, a discussion of the study findings, and recommendations for future research.

CHAPTER I: ENDNOTES

1. See Industry Surveys (New York: Standards & Poor's Corp., 1979). pp. 12-22; and Richard F. Kubi, "Training Problems Associated with EDP Auditing and Opportunities for Improvement," in EDP Audit Symposium-1978 Proceedings, ed. Joseph L. Sardinas, Jr. (Amherst: University of Massachusetts, 1978), p. 7-8.

2. Marilyn Bohl, Information Processing, 3rd ed. (Chicago: Science Research Associates, Inc., 1980), pp. 334-352.

3. Cyrus F. Gibson and Richard L. Nolan, "Managing the Four Stages of EDP Growth," Harvard Business Review, January-February 1974, pp. 76-88.

4. Bill Smiley, quoted in Frederic K. W. Miller, "Obsoleting the Old Role," Infosystems, June 1980, p. 69.

5. See Bill D. Colvin, "Computer Crime Investigators: A New Training Field," FBI Law Enforcement Bulletin, July 1979, p. 1; and Lindsay L. Baird, Jr., "Federal DP Crime Bill: A Much-Needed Measure," Computerworld, May 26, 1980, p. 64; and the Congressional Record Proceedings and Debates of the 96th Congress, 1st session, Vol. 125, No. 7, January 25, 1979, p. 5720.

6. See Brandt Allen, "The Biggest Computer Frauds: Lessons for CPA's," Journal of Accountancy, May 1977, p. 56 and "Computer Fraud," Financial Executive, May 1971, p. 41; Robert L. Stone, "Who is Responsible for Computer Fraud," Journal of Accountancy, February 1975, p. 36; and Tom Alderman, "Computer Crime," Journal of Systems Management, September 1977, p. 32; Donn Parker as quoted in "The Computer Thieves," Newsweek, June 18, 1973, p. 112; and several others.

7. Stanford Research Institute, Systems Auditability and Control Study: Data Processing Audit Practice's Report (Altamonte Springs: Institute of Internal Auditors, [1977]), p. 7.

8. Paul Macchiaverna, *Internal Auditing* (New York: The Conference Board, [1978]), p. 4.

9. *Foreign Corrupt Practices Act of 1977*, U.S. Code, Title 15, Section 78a, 1976 Edition, Supplement 1.

10. Macchiaverna, *Internal Auditing*, p. 15.

11. *Standards for the Professional Practice of Internal Auditing* (Altamonte Springs: Institute of Internal Auditors, [1978]), p. 1.

12. Macchiaverna, *Internal Auditing*, p. 15.

13. *Standards for the Professional Practice of Internal Auditing*, pp. 200-203.

14. U.S. Congress, House Subcommittee on Oversight and Investigation of the Committee on Interstate and Foreign Commerce, *Federal Regulation and Regulatory Reform*. 94th Congress, 2nd session, October 1976, p. 31.

15. The Independent Auditor's Responsibility for the Detection of Errors or Irregularities, *Standards of Field Work*. (Published for the AICPA by Commerce Clearing House, 1979), pp. 323-326.

16. *The Commission on Auditors' Responsibilities: Report, Conclusions, and Recommendations* (New York: AICPA, [1978]), p. 36.

17. See Richard W. Cutting, Richard J. Guitinan, Fred L. Lilly, Jr., and John F. Mullarkey, "Technical Proficiency for Auditing Computer Processed Accounting Records," *Journal of Accountancy*, October 1971, pp. 74-80 and Elise G. Jancura, "Technical Proficiency for Auditing Computer Processed Accounting Records," *Journal of Accountancy*, October 1975, pp. 46-59.

CHAPTER II

LITERATURE REVIEW

This chapter presents a review of the auditing and data processing literature related to this study. It provides the reader the relevant study context. During the early stages of the study, the literature review served three major purposes. First, it provided the basis for selecting and refining the research subject to insure that the study could potentially make a contribution to the field of EDP audit. Second, it provided insights useful in determining the study methodology. Third, it provided information useful to the construction of the questionnaire.

Numerous articles have addressed themselves to the different aspects of computer audit techniques. However, relatively few studies have explored the nature of recent computer advances and fewer still have examined the area of auditor data processing knowledge requirements. The literature did identify and discuss many of the major auditor data processing areas, thus providing a basis for further defining data processing knowledge requirements. The following discussion first addresses the computer developments most relevant in terms of their impact on the audit of computer based management information systems. Attention then is given to other developments that had their genesis in the rapid advances and uses of computer technology. The changes these developments brought to the nature of the management information system from an audit perspective is subsequently considered. The discussion to this point provides the background for a review of the audit techniques which have been developed to allow more effective audits of the increasingly complex management information systems. The review concludes with an examination of the literature that addressed the impact of these events on the data processing knowledge requirements of internal and external auditors.

Computer Developments Most Relevant to Auditing

Since the introduction of the first commercially available computer, the UNIVAC I in 1951, and the first business installation in 1954, computers have increasingly forced changes in the management, operation, and structure of business and government organizations. These changes have resulted due to the economies that can be realized through the use of computers. Over the years computer processing costs per unit of production have consistently decreased while computer capability and capacity have rapidly increased. As an example, processing speeds have increased many fold with their measurement evolving from milliseconds and microseconds to nanoseconds and pico-seconds. Even further, the availability of easily accessed storage has increased from thousands of characters to billions of characters (1). The result has been a dramatic increase in the number of computers in use and in the complexity of the systems themselves.

One of the major factors that caused the increased complexity of computer systems was the increase in user confidence that resulted from successful data processing applications. As users gained experience they often expanded the number of applications processed on their computer systems. When they reached the system capacity they expanded or replaced their existing systems with larger, more complex computer systems that had greater processing capabilities.

Another major factor was the advances realized in the software area. The development of translating programs provided programmers the capability of developing application programs using mnemonic and English-like programming languages rather than machine readable code (2). This by itself resulted in substantial increases in programmer productivity. Software firms were formed to develop general purpose application programs for the growing base of computer users. During the late 1950s, the United States Government and computer manufacturers developed and standardized the first business high level English-like programming language (COBOL). This became particularly significant in the late 1960s and early 1970s when COBOL compiler testers were developed by the U.S. Navy under Dr. Grace Hopper. Users were free to upgrade their computer systems or change to a different computer manufacturer's equipment without converting their application programs to a new program language or retraining their programmers. COBOL is the most widely used business oriented language in use today (3). In 1969, IBM separated the pricing and sale of its application program packages and services from its computer hardware and the operating programs required to make them run (4). This stimulated further the formation of software firms and the availability of general purpose application programs.

Several other factors led to increasing the complexity of computer systems. Computer networks were constructed consisting of two or more computers communicating with each other by means of an integrated communications subsystem. These systems are referred to as distributed systems. They greatly complicate both program and data flow through the multiplication of the number of processing units, storage units, and communication channels over which programs and data can be processed. To complicate the audit further, the processors and terminals are frequently geographically separated regionally, nationally, and even internationally (5).

The complexity of program and data processing on a single processing unit has been increased through a more complex logical relationship of data stored within the computer system and also between the data files and the application programs which give access to data. Conventional systems were logically constructed to have a series of files and programs, with the programs constructed to give access to a specific file or set of files. The programs and files were interdependent, resulting in the duplication of data in different files. This caused problems of accuracy since the various files were updated by different organizational entities, at different times, and often with different information.

A new logic structure, referred to as a data base management system (DBMS), organized the data into a single data base, thus making the data independent of application programs. While DBMSs improve data accuracy, eliminate much undesirable data redundancy, and improve access to the data, they also complicate the job of the auditor. A DBMS constitutes another software system that performs an interfacing function between the operating system and the application programs. It is usually an add-on system that is used for only a part of the applications being processed at a given installation. DBMSs increase the complexity of system access control due to their add-on nature and data independence which potentially allows any application program to gain access to any data field. DBMS systems also allow people from the user departments programming access to the system, because the programming languages are easy to learn. These factors significantly increase the difficulty of the auditor's examination of access and application program development controls. In addition, the auditor must be aware that logic can be imbedded in the DBMS software by error or design that can alter the processing of audit or the client programs or data (6).

A programming technique called multiprogramming was developed to improve the efficiency of computer processing units by providing for the concurrent processing of more than one application program (7). Technological advances had increased the speed of the processing units until they were processing several thousand instructions per second, while the speed of data entry remained very slow, depending on input mode; for example, keyed, card, and tape. Without multiprogramming, it was not unusual to use less than fifty percent of the processing unit's capability. This advance had the benefit of forcing a modular program construction which is easier to document, review, and understand. However, the multiple, concurrent job streams made it more difficult to understand the system, required more complex operating system software within which to conceal unauthorized code, and made it more difficult to make judgments on the use of data processing resources. The multiple job streams also introduced a new auditing complication--the possibility of one program giving access, changing, destroying, or copying data of another program by accident or design--without authorization and potentially without leaving an audit trail.

Computer manufacturers began designing and building computers that housed in an integrated manner more than one processing unit (8). These multiprocessing machines incorporated the multiprogramming technology, making them extremely complicated systems. The auditing impact was again to increase the difficulty of understanding the system, to provide more system software in which to conceal unauthorized code, to create greater difficulty in assessing the use of data processing resources, and to introduce the problem of program and data security as a result of the multiple processors with multiple, concurrent job streams.

Finally, advances in peripheral equipment have significantly increased the methods and numbers of locations used by businesses to enter data. These include mark sense, audio, optical character recognition, magnetic ink character recognition, point of sale, cathode ray tube, teletypewriters, and others. The primary impact of auditing relates to control. Unauthorized use is a problem, because these devices are frequently located in uncontrolled areas. Data access is also a problem, since these systems are potentially capable of any type of processing unless effective facility, hardware, and software controls are used.

Other Computer Related Developments

There are several other developments that are relevant to auditor data processing knowledge requirements. The historical trend of increasing computer capability and complexity came about as a direct result of increases in the complexity of American society and the information needs of business and government organizations. Business organizations became larger, more geographically dispersed, more diversified and international in scope. Accounting, auditing, and data processing grew in complexity in response to society's needs. The growing body of knowledge quickly outpaced man's ability to master and remain current within these respective fields. This resulted in specialties developing along functional and industrial lines. Some examples include tax, financial, EDP auditing, communications, distributed systems, and DBMSs. It also resulted in the use of the team approach and the use of specialists to provide the expertise required to complete the audit adequately.

One development that resulted from the increasing computer complexity and expanding body of data processing knowledge was the formation of the EDPAA in 1972. This organization has taken the position that the effective audit of computer based accounting systems requires considerably more data processing knowledge than most accounting school curricula provide, more than is required to pass the CPA exam, and more than is required by the professional organizations for professional development. In the fall of 1976, the EDPAA formed the EDP Auditors Foundation for Education and research to establish a forum to provide greater recognition of, and emphasis on, EDP audit education and research. Dissatisfied with the minimum level of knowledge required by existing certification programs, the EDP Auditors Foundation established an EDP audit certification program on June 20, 1978. The EDPAA has a respectable following for an emerging professional organization, especially when one considers its brief existence and its specialized membership. Its membership has steadily grown and currently numbers about 4,400 members (9).

The question of the scope of auditor responsibility was raised to national prominence with the discovery of the two billion dollar fraud at Equity Funding Corporation of America. The fraud began in 1964 and was brought to an end in 1973 as a result of information provided by an employee who had been released due to overstaffing--not as the result of an audit. The Equity case resulted in the second largest bankruptcy in the history of the Chapter X provisions in the U.S. Bankruptcy Code. The major contribution of the computer was to create 64,000 bogus insurance policy numbers and to generate randomly 30,000 funding programs. Microfilm was the major record storage medium rather than computer files. While it has subsequently been found that the computer was not the main villain, the case has focused attention on the need to reassess the EDP qualifications and responsibilities of auditors. The Equity Funding case is one of several hundred fraud cases involving computers which went undetected by internal and external auditors, even though the frauds occurred over several months and in a few cases, over several years (10).

The last major computer related development came in December, 1977, when President Carter signed the Foreign Corrupt Practices Act. The Act made internal accounting control a matter of law for all U.S. businesses which are subject to the jurisdiction of the Securities Exchange

Commission (SEC) under the Securities Exchange Act of 1934. The law came about as a result of widespread instances of undisclosed, questionable, or illegal corporate payments that represented a serious breach of the SEC's system of disclosure and threatened public confidence in the integrity of the system of capital formation. According to the legislative history, the law was designed to prevent the use of corporate funds for corrupt purposes by requiring the maintenance of accurate records and improved disclosure. Title I of the act required that corporations:

> (A) Make and keep books, records, and accounts, which, in reasonable detail, accurately and fairly reflect the transactions and dispositions of the assets of the issuer; and
> (B) devise and maintain a system of internal accounting controls sufficient to provide reasonable assurances that:
>> (i) transactions are executed in accordance with management's general or specific authorization;
>> (ii) transactions are recorded as necessary (I) to permit preparation of financial statements in conformity with generally accepted accounting principles or any other criteria applicable to such statements, and (II) to maintain accountability for assets;
>> (iii) access to assets is permitted only in accordance with management's general or specific authorization and (iv) the recorded accountability for assets is compared with the existing assets at reasonable intervals and appropriate action is taken with respect to differences. (11)

The penalties of the act provide for up to $10,000 and five years imprisonment for each officer and $1,000,000 for the firm. Civil recourse is also available for any practices constituting violation of provisions of the act. More recent actions by the SEC make it clear that it intends to enforce the Act even where foreign bribery is not involved. Ernst & Whinney and others have pointed out that neither the Act nor professional literature provide criteria for evaluating the adequacy of systems of internal control. One last and potentially ominous aspect of the Act is the fact that it opens the door for legal interpretation. As auditors learned from the Adams versus Standard Knitting Mills case, the courts are not always guided by the refinements and guidelines found in generally accepted accounting and auditing standards. Finally, the Act is not an isolated development, but one of a sequence of actions taken by the SEC that has the effect of expanding auditor responsibilities and data processing knowledge requirements. The SEC is currently proposing public reporting of the adequacy of system internal controls and any material weaknesses that are identified and not corrected within the reporting year (12).

The most recent development is the emerging professional accountancy programs as they relate to EDP auditing. The need for such programs has resulted from many of the developments discussed earlier which have increased auditor knowledge requirements beyond what can be imparted in a four year program. The American Institute of Certified Public Accountants, the Institute of Internal Auditors, the Financial Executives Institute and others have supported the need for these programs and have been working with the American Assembly of Collegiate Schools of Business to establish the desired accreditation. The question raised by this development is to what extent do these new programs improve the data processing education of individuals entering the internal and external audit professions. An emerging competing, and more specialized alternative to this generalist approach for all entry auditing personnel is supported by several members of the IIA and AICPA, within the EDP Auditors Association. These emerging programs provide a more balanced coverage of accounting, auditing, and data processing. This latter issue will be discussed in greater detail with the study results.

The Impact of Computers on the Nature of Auditing and Management Information Systems

All accounting systems basically perform the function of expressing economic events in monetary terms with respect to assets, liabilities, ownership, revenues and expenses. Prior to the advent of the computer, the normal evolution of accounting systems was from strictly manual, to machine assisted, and then to punched card systems or some combination of each. This progression improved business efficiency, but had little impact on business organization, documentation, or the accessibility of information. These systems generally provided hard copy transaction documents, journals, general ledgers, subsidiary ledgers, trial balances, various working papers, historical files, financial statements, and other reports. For these reasons, the audit techniques and job knowledge remained relatively unchanged. This has not proved to be the situation with respect to computers. The impact of computer use has been described as revolutionary, exceeding the impact of electricity, telephones, automobiles, and television. The impact of computers on audit techniques and knowledge has been no less revolutionary.

The potential audit use and audit impact of the computer were apparent very early. Gregory Boni discussed the impact of the computer on the audit trail in a 1963 <u>Journal of Accountancy</u> article. He stated:

> . . . that it is not only possible, but it is very much a fact, that, between the data on a document and the final information which is printed out, the accounting steps have been processed and stored in or on material that is not visible to the human eye. (13)

His observations were especially accurate for the time and included the following:

1. The changed nature of the audit trail
2. The inquiry capability of computers
3. The increases in processing speed
4. The increased accuracy of computers
5. The concentration of many processing steps into one department
6. The concentration of accounting and operational data
7. The need to evaluate additional controls
   A. Program changes
   B. Access to handle transaction exceptions
   C. Magnetic tape
   D. Computer downtime records (14)

In 1968, Gordon Davis noted the two-fold impact of computers. The first impact was the introduction of a new technology that required auditors to expand their knowledge. The second impact resulted from the manner in which computers were used. He noted that the use of computers not only speeded up the processing of data, but also forced changes in the management information systems in use. While earlier systems tended merely to computerize existing clerical functions, later systems expanded in scope and operation, incorporating decision oriented analytical techniques not practical in earlier clerical systems (15). The impact was to make it more difficult to perform the basic audit steps which remained:

1. Gain an understanding of the system
2. Review the adequacy of the controls to ensure completeness and accuracy of the recording and processing of accounting data
3. Confirm that the system and related controls are functioning as described
4. Perform additional testing of the closing balances. The scope of such additional work would depend on the effectiveness of the systems and its controls (16)

Later, in 1969, John Wagner prophetically suggested some attributes that would characterize computer systems in the 1970s. These characteristics are descriptive of the systems required to support the more complex decision systems to which Davis referred. The described systems were possible with the technology available in the mid-1960s and have now become commonplace. The attributes were as follows:

1. A greater integration of information systems
2. More on-line, real-time systems
3. An increase in time-sharing and service bureau usage
4. Less operator intervention during processing
5. More transmission of data directly from one computer system to another
6. More optical scanning, less human conversion of input data
7. More input initially created in the form of electronic impulses, and less use of hardcopy surface documents
8. More CRT (visual) display units
9. Less hardcopy, more data stored in micro-electronic form (17)

The Impact of Computer and Related Developments on Audit Techniques

Since the introduction of computers, auditors have consistently been forced to increase their knowledge of data processing, to modify their audit procedures, and to audit computer based accounting systems adequately. Manual and machine assisted accounting systems leave a complete hard copy audit trail which auditors can examine to complete their audits. Punched card accounting machine systems are usually designed to provide hard copy audit trails. Computers use different storage mediums that cannot be read directly but must be read through the use of application and operating system programs. In addition, the actual processing of the data is accomplished electronically and cannot be directly observed. Finally, computer applications have been developed for improving efficiency and economy, often necessitating the elimination of some of the traditional separation of duties found in less sophisticated accounting systems (18). To aggravate the above conditions further, the business computerized management information systems have become more vulnerable to unauthorized modification, destruction, and duplication. This is due to the high concentration of business data and procedures stored in the data bases, the increased and often widely dispersed methods of electronic entry, and the emergence of highly skilled data processing professionals (19).

Early business computers were not much more than advanced calculators with limited memories. They were batch processing machines that had one linear job stream and minimal operating systems (20). Generally, auditors had little if any computer knowledge and continued to audit as if the computer did not exist (21). Typically, auditors selected source documents, traced entries through available computer printouts and examined the resultant entries in summary accounts. The phrase, "auditing around the computer," was applied to this procedure, since only the data input-output relationship was examined. The computer was referred to as the "black box." This technique was adequate, if the application program and/or operating system had not been modified and if the auditor understood the processing system along with the appropriate internal controls. If the auditor lacked this understanding, he would not have had the basis for relying on the accounting EDP controls. In larger and more sophisticated systems, there is an enormous potential for exceptional conditions in both the application and operating system programs (22). In addition, the audit trail is incomplete in terms of hard copy and the computer output is too voluminous for manual examination. No assertions nor inferences can be made with respect to data not examined. Finally, it is safe to conclude that the auditor using this technique would not discover unauthorized program logic and would be unlikely to detect exceptional conditions. A sound data processing knowledge is essential for auditing the more recent technology based systems.

A second group of auditing techniques was developed and referred to as "auditing through the computer." The term generally refers to all techniques that require the auditor to examine processes within the "black box." The difficulties that face the auditor using these techniques are to verify that: (1) established man-machine procedures were consistently followed; (2) application program logic was consistent with published policy and procedure; and (3) the programs tested were in fact the programs used to process the data. Authors occasionally used the term "auditing through the computer" to describe more restricted techniques. These techniques were usually limited to some type of application program review. All of these techniques were superior to the earlier "around the computer" techniques because they usually involved the use of operational computer programs to check the results of test transactions. These techniques also required that the auditor have sufficient data processing knowledge to assess intelligently the accounting controls designed into the application programs. This was normally accomplished through a review of documentation, program logic, and the results of the test transactions. However, there still could be no assurance that the programs tested were the ones actually used to process the transactions on a day-to-day basis (23).

The integrated test facility (ITF) is an audit technique that was designed to minimize at least the problem of assuring that the program tested was in fact the program used to process the transactions under examination. As the name implies, the test transactions are integrated into the regular processing system as if they were real business transactions. Auditors then input the transactions based on their audit plan, without prior coordination with functional managers or data processing personnel. They then can compare the actual versus predetermined results to evaluate system conformance.

This technique is an improvement over the use of test transactions processed under controlled conditions, but can be rendered ineffective by a knowledgeable programmer. The weakness of this technique lies in the need for controls to assure that the test data do not get mixed into the regular records and reports. When these controls are embedded in the application and operating system software, they provide the potential for alternate application programs to be used with or without modification of the operating system. The program modification weakness can be overcome by processing the transactions without modifying software and then having the auditors clear the test data through the use of adjusting journal entries. The latter usually has been found to be unsatisfactory because: (1) inaccuracy is introduced into operational reports; (2) the adjusting entries tend to create additional errors; and (3) the manual effort is costly and tends to limit the sample sizes and breadth of transactions sampled (24).

A fourth technique involves the sampling of live transactions as they are generated and processed in the day-to-day business environment. The auditor selects the transactions to be examined and tags them with a unique code which allows the computer system to track the transactions as they are processed through to completion. The auditor is then provided hard copy or a cathode ray tube display of processing details. The application software must contain logic that identifies the unique code in the selected transactions at the program locations where before and after "snapshots" are taken of the transaction and related data. The locations are usually: (1) the transaction entry point into the computer system; (2) the entry and exit points for all programs used to process the transaction; (3) points where the transaction is used in conjunction with another record; and (4) major program processing logic points where the data is materially changed.

A weakness of this audit technique is that the sampling of day-to-day transactions is often accomplished during in-line processing and will not include transactions that are processed at other times, and which should be examined. However, the sampling of live transactions is superior to the use of the ITF because of the lower profile of the required implementing program logic and the use of actual data. A knowledgeable programmer can still use the implementing program logic to select alternate programs conditionally to process transactions not selected. This weakness renders the technique impotent to detect irregularities or fraud. The technique suffers a second weakness of being unable to assure that all program logic sequences are traversed. An enhancement to this technique involves the identification, display, and reporting of unusual transactions. This enhancement requires that even further logic be incorporated into the application programs or the operating system. This provides an added safeguard and audit convenience but does nothing to resolve the weaknesses discussed (25).

A fifth auditing technique uses mapping techniques to examine the processing logic of application programs. One type of mapping technique prepares a flow chart based on program logic. This technique was originally designed for data processing management but has been effectively used by auditors to prepare for audits, to evaluate existing program controls, and to assess the need for additional controls. It has also been useful for conducting audits of program development projects. More generally the term mapping refers to specialized programs designed to identify the logic paths in application programs. It identifies those parts of the application programs that are functional versus those that are not executed. Mapping is beneficial in identifying unneeded code and also potential segments of program logic that are actuated under special conditions to include unauthorized purposes. Mapping was also originally used by data processing management to study the data flow through application programs in order to optimize the efficiency of programs. Auditors use the technique to evaluate the extent of system testing and later to determine the need for additional testing. Mapping is also used in conjunction with other techniques (26).

The last technique to be reviewed concerns the use of generalized audit software (GAS). This software performs a wide variety of functions but generally assists auditors in retrieving and analyzing data stored in some machine readable form. Some of the common functions include:

1. Checking extensions
2. Checking the footing of a file
3. Selecting items for further audit vouching by such criteria as random sample and stratified sample
4. Testing for certain types of conditions, such as credit balances
5. Comparing and matching data contained in separate computer files
6. Statistical analysis
7. Confirmations using computer file information and special forms (27)

Many different versions of GAS are available that perform a wide range of functions in the general purpose software market mentioned earlier in the discussion of computer developments. These program packages became feasible because of the development and wide use of high level languages. They are economically attractive due to the steady increase in programming cost and the software houses' ability to spread the development cost over many buyers. Finally, they give the auditor programming independence from data processing, since they operate on the basis of parameters and can be run with minimal training. Many of the public accounting firms have developed their own packages. GAS packages must operate in conjunction with the computer operating system and as a result can be compromised by a proficient systems programmer through modification of the operating system programs to lock out access to identified records or modify the program output (28). Very few GAS programs are available that can gain access to data through DBMS software structures (29).

The Impact of Computer and Related Developments on Auditor DP Knowledge Requirements

The Internal Auditor

Until recent years, there seems to have been little effort to define the data processing knowledge requirements of internal auditors. The Conference Board's reports on internal auditing provide at least one explanation for this. According to its 1963 report, internal auditors were auditing in a fashion analogous to external auditors, consisting primarily of financial audits and attesting to the accuracy and completeness of financial statements. Since both internal and external auditors were conducting the same type of audits and in many cases against the same systems, their data processing knowledge requirements were the same. The early studies concerning external auditor data processing knowledge requirements were also applicable to internal auditors. However, according to the 1977 Conference Board study, internal auditors are now devoting approximately equal time to nonfinancial audits. They evaluate controls, check compliance with policies and procedures, and test reporting systems in the nonfinancial areas of corporate operations as well as in the financial areas. They also include evaluations to determine how efficiently and economically management uses its resources and how effectively it achieves its objectives (30). This broadening of the internal auditors scope is reflected in the IIA's Standards for the Professional Practice of Internal Auditing. Excerpts from the standards state:

> The scope of the internal audit should encompass the examination and evaluation of the adequacy and effectiveness of the organization's system of internal control and the quality of performance in carrying out assigned responsibilities. . . .
> - Recognize that management exercises general direction on the scope of work and activities audited
> - Ascertain whether the system established provides reasonable assurance that the organization's objectives and goals will be met efficiently and economically
> - Ascertain whether the system is functioning as intended
> - Ascertain whether the organization's objectives and goals have been met (31)

The difference between the scope and responsibility of internal and external auditors should be reflected in their data processing knowledge requirements. One means of gaining insight into this difference is to look at the experience of other countries. The Canadian economic system is comparable to that of the U.S., and the Canadian Institute of Chartered Accountants (CICA) has been very active in the EDP audit area. The CICA completed its first report on the impact of computers in 1967. Due to the many significant computer advances, the CICA began in 1970 to re-examine the impact of computer developments on auditor data processing knowledge requirements. Its second report was published in the September, 1974, <u>CA Magazine</u>. It did not identify universal data processing knowledge requirements, but instead specified data processing knowledge requirements based on eight classifications relating to individual responsibilities. This approach was rationalized on the basis that their members had many diverse responsibilities beyond the field of EDP which restricted available time. Their emphasis was on obtaining sufficient data processing knowledge. The eight classifications included the user, data center intermediary, administrative manager, financial manager, external auditor, external advisor, internal financial auditor, and the internal management auditor. The categories of concern to this study are the external auditor and the internal management auditor. Fig. 5 provides the recommended data processing principles, skills, and length of instruction. The CICA study concluded that internal auditors require a higher level of data processing knowledge.

The only major study that addresses the data processing knowledge requirements for internal auditors is the IIA's SAC study. The SAC study approaches internal auditor data processing knowledge in a pragmatic manner similar to that of the CICA. The SAC report states:

> The content of EDP audit training programs depends upon the sophistication of data processing application systems, the data processing background of the internal auditors, and the EDP audit tools and techniques required to audit the organization's data processing activities. (34)

Computer Principles and Skills	External Auditor	Internal Auditor
Principles		
Processing and operations	4	4
Programming and software	3	3
Systems design and analysis	3	3
EDP management	1	1
Skills		
Control	3	3
Applications	0	3
Resource Management	0	2
Auditing	4	4
Total days education	18	23

Fig. 5. CICA Recommended Computer Principles, Skills, and Minimum Days of DP Education (33)

The objectives of the EDP program are to:

1. Provide the internal audit function with sufficient EDP audit knowledge to effectively audit computer applications systems and related data processing activities
2. Develop and maintain an awareness of the best EDP audit tools and techniques available to the internal auditor
3. Develop and maintain an awareness of computer technology as it relates to EDP auditing in order to anticipate new requirements (35)

The report recommends that auditor data processing instruction be given in two phases. The first phase is for those auditors who have little or no data processing experience and should include terminology, hardware, and the data processing environment. The second phase expands on the first phase and includes greater depth in each of the areas covered in the first phase. In addition, it should cover computer architecture in some detail, covering such items as operating system characteristics, memory management systems, and communication systems. The study lists each audit technique and identifies the data processing knowledge requirements needed to use that technique effectively. It is therefore up to each audit staff to determine the level of data processing knowledge required based on the system under examination and the techniques to be used by each auditor.

The External Auditor

The first study of importance was the 1967 "Study of the Common Body of Knowledge" funded by the Carnegie Corporation and the AICPA. The increasing use of computers in the 1960s led the authors to identify a general level of data processing knowledge requirements for all external auditors. The requirements were as follows:

1. A basic knowledge of at least one computer system. This implies a knowledge of the functions of the component parts, of the general capabilities of the system, and of the more universal terms associated with the computer.
2. The ability to chart or diagram an information system of modest complexity. This means that he should be able to comprehend the procedural steps in a system and utilize basic diagram symbols that describe the system clearly and precisely.
3. A working knowledge of at least one computer language together with his overall knowledge of information systems, the beginning CPA should be in a

> position to design a simple information system, program it, and proceed to debugging and testing. (36)

The above data processing knowledge requirements for external auditors were developed further in the October 1971 Journal of Accountancy article by Cutting, Guiltinan, Lilly, and Mullarkey. These authors indicated that the requirements they identified were not universal but that each firm must assess the impact of computers and reach its own conclusion. They did however point out that the second standard of field work required that there be a proper study and evaluation of the existing internal control as a basis for reliance thereon and for determination of the resultant extent of the tests to which auditing procedures are to be restricted. Further, they declared that when a computer is used to process significant financial information, an ability to both understand and evaluate the EDP system is very important. Finally, Cutting and the others stated:

> Because it is impractical to train and continually update each staff accountant to a very high level of expertise in computer auditing, three different proficiency levels for persons assigned to audits are appropriate:
> (1) the general audit staff member,
> (2) the computer audit specialist, and
> (3) the data processing professional. (37)

Prior to detailing the data processing knowledge requirements, Cutting and others wrote that:

> Since virtually all staff members in a public accounting firm might be assigned to an audit engagement of this type, the described capabilities may be considered as minimum knowledge requirements for everyone engaged in public accounting. (38)

The knowledge requirements were as follows:

1. Understand basic computer concepts: Understanding computer processing concepts and differentiation between functions of central processing and peripheral equipment
2. Understand and be able to analyze the concentration of controls in an EDP environment
3. Understand systems flowcharts and descriptions of computerized systems
4. General familiarity with at least one computer programming language
5. Understand in a general way the use of computer auditing software
6. Understand concepts of file processing (39)

In the latter part of 1974, the AICPA issued a statement of auditing standard (SAS) No. 3, "The Effects of EDP on the Auditor's Study and Evaluation of Internal Control." The statement recognized that audit procedures used in the evaluation of accounting control to determine the nature, timing, and extent of audit procedures to be applied in the examination of financial statements could be influenced by the method of data processing used. SAS No. 3 further stated:

> If a client uses EDP in its accounting system, whether the application is simple or complex, the auditor needs to understand the entire system sufficiently to enable him to identify and evaluate its essential accounting control features. (40)

This raises the question as to what procedures and what auditor data processing knowledge are required to execute the procedures effectively.

Recognizing the need for more and better EDP training for accountants and auditors, a task force of educators was formed from the American Accounting Association's committee on accounting education and from the AICPA's computer education subcommittee. The task force reviewed the emphasis on EDP in undergraduate auditing curricula and concluded that there was minimal coverage given to EDP, and that the coverage that did exist gave little or no attention to the effect of EDP on auditing. They recommended, as a minimum, that the following topics be taught in the undergraduate auditing curriculum:

1. EDP technical proficiency requirements for the staff auditor
2. The review, evaluation and study of internal control in an EDP environment
3. Auditing a computer system without using a computer
4. Using the computer to perform compliance and substantive tests of the records produced by a computer system
5. Auditing data processing records produced by a computer service center (41)

The task force adapted the Cutting et al. 1971 article, referred to earlier, as embodying the minimum technical proficiency requirements for the staff auditor. For the second topic, the task force indicated that auditors must be able to evaluate clearly the EDP system as it relates to the accounting system. The major knowledge areas were identified as:

1. General controls in an EDP system
   A. Plan of organization
   B. Data processing system development procedures
   C. EDP operating and control procedures
2. Application controls in an EDP system
   A. Controls over the input of data
   B. Controls over the processing of data
   C. Controls over the output of data
3. System documentation
4. Flowcharting a computerized accounting system
5. The change in an audit trail from a manual system to a computerized system
6. Internal Revenue Service guidelines for EDP records
7. Data Security
8. Physical security (42)

In 1975, the AICPA's computer education subcommittee asked Dr. Elise G. Jancura to update the earlier 1971 Journal of Accountancy article. She observed that EDP typically affects the form of accounting data and to an extent affects the nature of the corroborating evidential matter due to the replacement of hard copy in systems with computer records. She stated that:

> All of the developments in the field of computer and software systems require a corresponding strengthening of the auditor's technical background so that the auditor can discharge the duties required in the proper performance of an audit and adhere to the generally accepted auditing standards adopted by the American Institute of Certified Public Accountants in its Code of Professional Ethics and SAS No. 1.

Her assessment of these developments was that the auditor must be able to interrogate and evaluate the system directly. Further, that for the auditor to perform the attest function properly, he must be able to identify and understand the systems having significance for the financial records and to test the systems for compliance (43).

Dr. Jancura's 1975 article contributed substantially to the definition of external auditor data processing requirements. She observed that the use of operating systems and techniques such as teleprocessing, data base management systems, multiprogramming, and multiprocessing had increased the depth and breadth of auditor data processing knowledge requirements to the point that the 1971 distinction between the data processing knowledge requirements of the general audit staff member and computer audits specialist was no longer valid. The difference should be only in the depth of data processing knowledge.

A major point made by the Jancura article is that the use of a computer audit specialist does not excuse the staff auditor from developing enough knowledge of computer procedures and techniques to perform the judgmental function assigned by the professional standards. The staff auditor should not use the services of the specialist as a replacement for personal judgment. The knowledge level of auditors in charge of an audit is given as that required to plan and supervise the audit adequately. The staff auditor must have the data processing knowledge to address the computer at two levels:

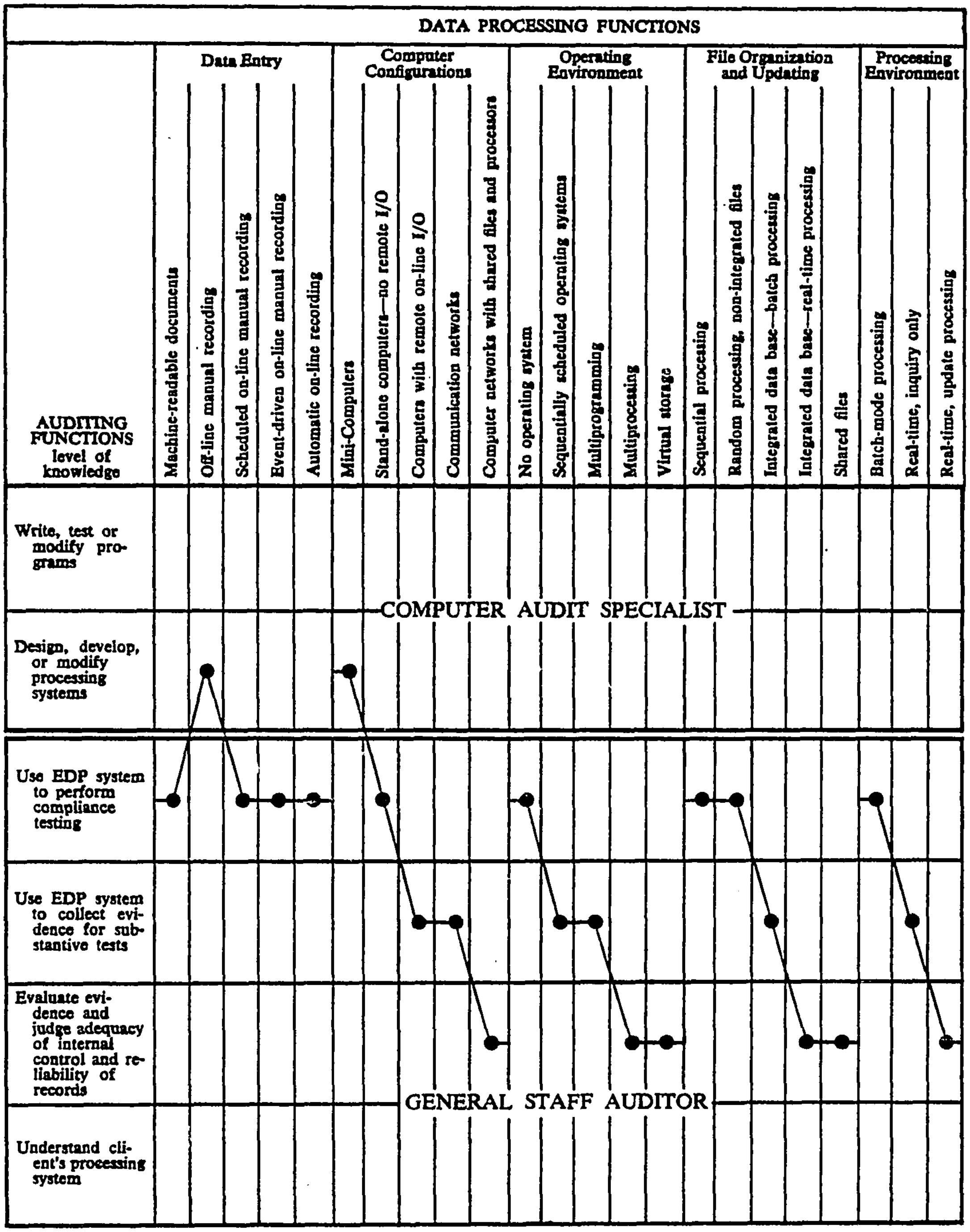
1. To be able to evaluate the impact of the client's computerized activities on internal control
2. To determine effectively the use of the computer to perform compliance and substantive tests (44)

Dr. Jancura uses the term "general staff auditor" primarily to refer to the senior accountants. However, in an explanatory footnote she indicates that the requirements discussed are also those that a junior accountant should possess or be actively developing (45). In discussing the minimal knowledge requirements for 1975, Jancura makes the point that if general staff auditors are to continue to have the basic audit responsibility, auditors must continue to expand their knowledge to include a basic understanding of many data processing techniques formerly known solely to computer audit specialists. The minimum data processing knowledge requirements should include:

1. A basic understanding of computer systems including equipment components and their general capabilities
2. A basic understanding of widely installed computer operating systems and software
3. A general familiarity with file processing techniques and data structures
4. Sufficient working knowledge of computer audit software to use existing, standardized audit packages
5. Ability to review and interpret systems documentation including flowcharts and record definitions
6. Sufficient working knowledge of basic EDP controls to:
   A. Identify and evaluate the controls in effect in a client's installation
   B. Determine the extent to which such controls should be tested and to evaluate the results of such tests (although not necessarily to execute such tests)
7. Sufficient knowledge of EDP systems to develop the audit plan and supervise its execution
8. A general familiarity with the dynamics involved in developing and modifying programs and processing systems (46)

Fig. 6 provides a summarized graphical profile of the auditing and data processing functions of the general staff auditor and the computer audit specialist (47).

In October, 1974, the AICPA Board of Directors established the Commission on Auditors' Responsibilities to study the role and responsibilities of independent auditors. The Commission met monthly for two and one-half



SOURCE: The Journal of Accountancy, October 1975.

Fig. 6. Knowledge Requirements for General Staff Auditors

years, publishing a tentative report for comment in 1977, and their final report in 1978. The reports deal with several issues, but the issues of concern to this study relate to the responsibility for detecting fraud and the quality of CPA education. The Commission recommended that audits be designed to provide reasonable assurance that financial statements are not affected by material fraud. To help evaluate whether the auditor has met these responsibilities, the Commission recommended that a concept of due professional care be used as a guide for judging audit performance. They specified that due professional care should include requirements to: . . .

1. Establish effective client investigation programs
2. Immediately pursue any evidence that suggests that management may be untrustworthy
3. Resign if the evidence in No. 2 can not be refuted
4. Observe conditions suggesting predispositions to management fraud
5. Maintain an understanding of a client's business and industry
6. Be concerned with controls related to fraud prevention and detection (48)

The Commission was highly critical of the education received by auditors. Their final report charged that:

> . . . many new accountants find that their education did not adequately prepare them for the responsibilities they face after graduating. Every year, public accounting firms spend amounts greater than the budgets of many business schools training newly hired accountants, almost all of whom have just received accounting degrees. (49)

Their recommended solution is a seven year professional program run by CPAs separate from the business schools (50). The Commission recommendations have little if any short term impact on auditor data processing knowledge requirements, but certainly raise the question as to the proper role of schools of accounting with respect to internal auditing, external auditing, government auditing, and the other management accounting versus professional organizations.

In 1977, Michael J. Cerullo analyzed the extent of computer knowledge needed by public accountants engaged in auditing, management advisory services, and taxation. He then used a random survey of 550 New York CPAs (267 responded), to determine if they were acquiring the recommended body of knowledge. For the auditing area, Cerullo used the 1966 common body of knowledge, the 1971 Cutting, and the 1975 Jancura studies as the knowledge base. He emphasized the need for a good working knowledge of basic EDP controls as the most important objective for the auditor. The objectives of the controls were to protect against mistakes, loss of data, destruction of information, and fraud. The major categories of controls which he used were as follows:

1. Organization or management
2. System design
3. Personnel
4. Segregation of duties
5. Documentation
6. Review process
7. Machine
8. Input
9. Output
10. Processing
11. Security measures
12. Audit (51)

The survey results documented the very grim status of external auditor data processing knowledge. No group of respondents was close to meeting the data processing knowledge requirements established years earlier in Horizons for a Profession. The study further showed a strong inverse correlation between a respondent's data processing knowledge and his years of external auditing experience. The study results relating to auditor knowledge levels are provided in Fig. 7.

Computer Knowledge Areas	Extent of Knowledge				
	Expert	Good	Average	Slight	None
System components	6	20	16	31	27
System controls	8	18	20	20	34
System design	11	8	9	26	46
Flowcharting	9	11	11	28	41
Test deck use	0	17	17	21	45
Programming	4	6	0	17	73
Average	6	13	12	24	35

Fig. 7. The Extent of Auditor Computer Related Knowledge (52)

Summary

This chapter has presented a review of the literature related to this study of the data processing knowledge requirements of auditors. The discussion has established the dynamic historical increase in the capabilities and complexities of computer systems. It has also pointed out that computer developments have changed the nature of auditing, increased auditor data processing knowledge requirements, and required the development of new auditing techniques. The impact of computer frauds, the Foreign Corrupt Practices Act, management concern, and the actions of the SEC have increased the breadth and depth of auditor data processing knowledge requirements. The evidence is becoming continually more persuasive that the accounting and data processing bodies of knowledge have reached the point where four year accounting programs are inadequate to educate auditors to a level acceptable to the profession. Even further, the thesis that auditors should be predominantly accountants is being challenged by a new school of thought. This new school of thought asserts that the extensive and increasing use of computers in accounting and auditing, coupled with the increasing complexity and depth of the data processing body of knowledge, has increased to the point that auditors must be substantially educated in data processing as well as in accounting and auditing in order to be able to design and execute effectively audits of sophisticated computer based accounting systems. The emergence of the EDP Audit Association and the five year accounting programs seem to support this new emphasis. Finally, all of these factors support the need for a study of the impact of the current technology computers, fraud, and the requirements of the Foreign Corrupt Practices Act on the data processing audit knowledge requirements of internal and external auditors, which in brief, is the purpose of this dissertation.

CHAPTER II: Endnotes

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CHAPTER III

METHODOLOGY

Introduction

The methodology used to conduct this study was established after a thorough literature review and discussions with experts in the area provided the basis for finalizing the subject. The characteristics of a current technoloty computer installation was constructed to provide a common, known basis for determining auditor data processing knowledge requirements. The relevant portions of the internal (IIA) and external audit (AICPA) standards were exerpted to standardize the audit scope and responsibility. The audit scope and installation characteristics were used to establish the internal and external auditor data processing knowledge requirements. The literature, the characteristics installation, and an analysis of eight fraud cases were used to construct the open-ended questionnaire portion of the survey instrument. The survey instrument was then reviewed by four academicians noted for their interest and work in the EDP audit area. Their names are provided in Appendix A. The internal and the external audit questionnaires then were completed based on the researchers knowledge and experience, for use during the analysis of the survey results. The survey was then conducted using a three-phase Delphi technique. The internal and external auditors who participated in the study were selected on the basis of their competence in the areas of auditing and data processing. These experts made the data processing knowledge judgments on the basis of the internal and external auditor's scope and responsibility and the model computer installation. Knowledge profiles were constructed based on these expert judgments. The internal and external audit knowledge areas and items within the profiles were then analyzed for significant differences between them and the researcher's initial judgment, and differences between the internal and external audit experts. Finally, the audit profiles were compared with the data processing coverage provided in the curricula of eight five-year accounting programs. Conclusions were formulated and recommendations made for future research. The following discussions provide greater detail for each of these areas.

The Literature Review

The literature search provided invaluable insights into the existing body of knowledge relating to the audit of computer based management information systems. The role of external auditors is fixed by law and is financial in nature. According to the 1963 and 1979 Conference Board studies on internal control, the primary function of internal audit units was to concentrate their efforts in the financial areas where the risk of misappropriation or intentional manipulation was the greatest. However, computer frauds, payoffs, and SEC activities have caused business management progressively to increase the role of their internal audit staffs (1). This has created a need for internal auditors to enhance their data processing knowledge and competence, and this divergence of the internal and external audit roles is reflected in the literature. As a result, applied audit literature in the United States today is appropriately directed at either internal or external auditors--seldom both. The experience in Canada also reflects the need to separate internal and external auditor knowledge requirements (2). The literature review verified the need for further definition of data processing knowledge and requirements for both internal and external auditors. Much of the existing literature deals with the level of knowledge which auditors have versus what they should have, without reference to known system characteristics or technology. Definitions of internal and external auditor data processing knowledge requirements are contained in the SAC report for internal auditors and the Jancura articles for external auditors. The EDP Audit Foundation's body of knowledge was not evaluated because it had not been published at the completion of this study.

The Operational Hypothesis and Research Questions

The Operational Hypothesis

This study is based on the premise that auditors must have a knowledge of data processing in addition to accounting and auditing. According to Harry S. Broudy, people must have a knowledge of specifics before they can understand concepts or deal with change (3). There are many important concepts within a computer based management information system environment that can have a significant impact on the auditor's examination. Therefore, the individuals in the best position to make judgments on the content of the required data processing knowledge are those who have a knowledge of data processing in addition to accounting and auditing. It is also logical to conclude that auditors must have data processing knowledge before they can understand concepts such as computer internal controls, data storage, hardware controls, and the controls relating to the various types of software. Operationally, then, the determination of knowledge requirements is pivotal to improvement in the EDP auditing field. Finally, if auditing is a profession, the knowledge requirements should be evidenced in the professional curricula.

The Research Questions

The discussion in Chapters I and II established the need to define better the data processing knowledge requirements of internal and external auditors. For purposes of reader continuity, the research questions developed to guide the research and analysis are repeated here:

Major Question

What are the data processing knowledge requirements of internal and external auditors?

Subsidiary Questions

1. What data processing knowledge is required by internal auditors to audit current technology computer systems?

2. What data processing knowledge is required by external auditors to audit current technology computer systems?

3. What are the differences in the data processing knowledge required by internal and external auditors?

4. Do the curricula of the selected five year accounting programs recognize the data processing knowledge required by internal and external auditors? (a) internal auditors? (b) external auditors?

The Research Design

Use and Selection of Computer Fraud Cases

The limited ability of internal or external auditors to detect ongoing frauds and the increased incidence of computer fraud have increasingly concerned business management and the SEC. Even more distressing is the fact that so many cases are uncovered only by chance because the perpetrator simply gave up, or because the perpetrator became careless. Even further, several experts have indicated that, since so many of the known cases have employed such simple techniques, they cannot help but conclude that more sophisticated techniques are used but that these frauds go undetected. Finally, the literature review revealed that the analysis of computer fraud was primarily undertaken from a computer control perspective and did not identify the level of data processing knowledge required to identify an ongoing fraud. It is for these reasons that several computer fraud cases were reviewed to make sure that the computer installation model included common, current technology vulnerabilities, and the questionnaire included the knowledge items that would assure that auditors understood these control vulnerabilities and data manipulation techniques that made the abuse possible. These vulnerabilities and knowledge areas were incorporated into the survey instrument. The researcher recognizes that the prevention and detection of unauthorized computer use is of greater concern to internal auditors than it is to external auditors, because of differences in their audit scopes and responsibilities.

A review of Parker's, Whiteside's, and Allen's works was conducted in order to approximate the number of cases that would have to be reviewed to get a reasonably complete data processing profile. The Allen study provided the most useful computer fraud categories. The study broke down the fraud schemes into the following five categories:

1. Transactions added or altered
2. Transactions deleted
3. File changes
4. Program changes
5. Improper operation (4)

The eight cases that were reviewed did cover each of these categories. The published information on most cases was too incomplete to define clearly the system, but did adequately identify the technique used to perpetrate the fraud and the system vulnerabilities relevant to the fraud. The following guidelines for selecting the final cases were used in addition to Allen's categories:

1. Both financial and non-financial fraud
2. Frauds perpetrated by employees and outsiders
3. Emphasis on current technology in software and hardware.

A brief case description along with the data processing knowledge requirements suggested by the case is provided in Appendix B. The analysis of the fraud cases revealed that some of the more recent cases required greater data processing knowledge on the part of the perpetrator than did many of the earlier cases.

Use of the Hypothesized Current Technology Computer Installation Characteristics

The literature and the rapid rate of technological advances support the need for emphasizing the latest computer technology and minimizing the influence of data processing audit experience with data systems. First, advances in computer technology have consistently increased computer processing and data storage capacity while decreasing the physical size and special environmental requirements. Computer technology has concurrently decreased the cost of computers, placing complex systems within the range where it is economically advantageous for relatively small businesses. These larger capacity computers require more sophisticated control systems, are more vulnerable, and are more difficult to understand. Second, the current generation of system software is performing many more management and operational functions and has a substantially greater potential for manipulation. Third, the use of new processing concepts such as data base management systems, distributed systems, point of sale, and electronic funds transfer systems, is increasing rapidly. These processing techniques differ substantially from the more traditional techniques used with earlier systems. Their use quite often results in changes in the users' organizational structure and operating procedures. Fourth, the installation characteristics provide the reader the basis for evaluating the study results and also can be reviewed later to determine when the data processing knowledge requirements should be updated. These are the major reasons for using the computer installation characteristics.

The current technology installation characteristics were constructed on the basis of the literature review, discussions with experts, and twenty-one years' experience in the field. The installation incorporates many of the latest hardware and software processing features in terms of processing power, complexity, and vulnerability. It also incorporates many of the high vulnerability internal data processing operations increasingly found at data processing installations. A specific examples of the latter is the more frequent tendency of businesses to modify the operating system. The characteristics are not intended to characterize a typical computer installation, but instead they are to be used in conjunction with the audit scope and responsibility as a means to establish a common basis for determining the data processing knowledge requirements of internal and external auditors. The installation characteristics are as follows:

1. It is a distributed system with processing units and data bases located in functional areas that are geographically separated from the main computer center.

2. It uses multiprogramming techniques.

3. It has a network of different types of remote input/output devices that are widely dispersed throughout the organization. These devices include keyboard, CRT, point of sale, and intelligent terminals.

4. The system is used with time sharing services procured on a contractual basis. As a result, a part of the data base is located in a vender's computer which is operated by another business at a geographically separated location.

5. Software is purchased as well as developed on site. Programming is done on the distributed sites for applications unique to that location.

6. Several application languages are used such as COBOL, PL/1, RPG, FORTRAN, and BASIC.

7. One or more data base management systems is used. A report generation language is used by several non-data processing people to gain access to and update records in an on-line mode.

8. The operating system is modified on a regular basis in order to improve the efficiency of program development, provide a wider range of problem solving facilities, and improve the use of system resources.

9. The file structures include sequential, index sequential, randomized direct, and the DBMS indices.

10. Primary memory uses virtual memory management techniques.

11. Secondary storage includes tape and disk.

12. Most application programming is done through interactive terminals.

13. The applications are processed using batch, real time, and interactive processing.

14. The system includes one or more stand alone minicomputers.

15. The system supports word processing in addition to other more conventional business applications.

16. Data entry includes batch and interactive devices locally and at remote locations.

The Study Populations

Since this is a normative study, the relevant populations for the study results are the professionals in the fields of internal and external audit. For purposes of statistical analysis, the populations are defined as those internal and external auditors who are expert in the areas of data processing and auditing. The need to address internal and external auditors as separate populations was based on their different audit scopes and responsibilities, as discussed in the literature review.

The Use and Selection of Experts for the Survey

It became clear quite early in the study that the survey portion of the study must be completed by individuals, expert in the area of data processing and auditing. The results of the SAC, Cerullo, and Joint AAA-AICPA studies invalidate the currency of any auditor data processing knowledge requirements based on a random sample of practitioners. Simon indicates that "Expert opinion is indispensable when the judgment involves human values" (5). He further states, "In most cases, a few opinions will suffice, because, if the experts are really experts, there will be relatively little variation among their opinions. . . ." (6). The selection objective was to concentrate on recruiting the assistance of five to ten highly qualified experts from the internal and external auditing fields. Since some attrition was expected during the three phase Delphi process, eighteen internal and eighteen external audit experts were recruited, with the expectation that at least one-third from each group would complete all three phases.

Both the internal and external audit experts were selected from large firms. The reasoning was that the audit staff of large firms could be expected to have more experience with a larger number and greater variety of computer hardware, software, and applications. The internal audit experts were selected from different industries in order to eliminate any unique industry bias. The IIA provided a list of potential participants. The list was used to contact the few selected internal audit firms that appeared on the list. The external audit experts were selected from a list of the fifty largest CPA firms provided by the AICPA. Where possible, the CPA firms were selected from different geographical areas to minimize any geographical or geography-based industrial bias.

All of the participating experts were recruited by telephone. Initially, the top audit executives were contacted by telephone to see if their firms were interested in participating in the study. They were then asked to identify the individual most knowledgeable in the areas of auditing and data processing. The individuals identified were then contacted directly and provided with a brief summary of the study and survey procedure. In most firms the individual identified was someone other than the top audit executive. Two internal firms and one external firm declined to participate in the study. One of the internal audit firms was a bank. It was later reported in the news that the bank was under investigation for questionable practices. The second internal audit firm and the CPA firm indicated that they had no one who was expert in auditing and data processing. The names of the internal audit experts who completed all three phases are provided in Appendix C, along with the names of their firms. The external audit experts and their firms are provided in Appendix D. One external audit expert and his firm was not disclosed because his participation was contingent upon anonymity.

The Delphi Research Technique

Linstone and Turoff indicate that the Delphi technique is desirable when "The problem does not lend itself to precise analytical techniques but can benefit from subjective judgments on a collective basis" (7). They defined the Delphi process as:

> . . . a method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem. To accomplish this 'structured communication' there is provided: some feedback of individual contributions of information and knowledge; some assessment of the group judgment or view; some opportunity for individuals to revise views; and some degree of anonymity for the individual responses. (8)

The Delphi methodology was compatible with the subject and objectives of the survey portion of this study, completed by experts in the field. The need to use experts has been established. The judgments of the experts were applied to a complex subject and can be measured only on an ordinal scale. Finally, the structured communication process provided the opportunity for respondents to share insights, revise early judgments, and refine final judgments. The need for respondent anonymity with respect to their specific responses was essential to encourage candor and to assure the freedom of respondents to modify early judgments. The anonymity of the respondents and their firms was respected throughout the survey process. The experts executed the technique in the following three phases:

Phase I

A. Reviewed the audit scope, characteristics of computer installation, and open-ended questionnaire for completeness, clarity, and accuracy

B. Make initial judgments of the importance of the data processing knowledge areas and items in the open-ended questionnaire

Phase II:

A. Reviewed the audit scope and characteristic computer installation

B. Made the second judgments of the importance of the data processing knowledge areas and items after considering the group range, standard deviation, and mean from Phase I and any insights gained since the initial evaluation

C. Provided a brief summary of rationale for each judgment that was higher than the group mean plus one or lower than the group mean minus one

Phase III:

A. Reviewed the audit scope and characteristic computer installation

B. Made the final judgment of the importance of the data processing areas and items after considering the group statistics from Phase II, the shared, anonymous rationale, and any insights gained since the second evaluation

The researcher was fortunate in obtaining the cooperation of a group of internal and external audit experts who were knowledgeable and experienced in the areas of auditing and data processing.

The Data Collection Method

The three principal methods of data collection considered were personal interview, mail, and telephone (9). For reasons of cost, time, and scheduling, personal interviews were eliminated from further consideration. The use of the telephone was eliminated as the primary data collection method because of the length and complexity of the questionnaire as well as the cost. The Department of Production and Decision Sciences at Miami University agreed to fund a reasonable number of telephone calls to complete the survey. The above considerations, in addition to the following selected questionnaire advantages, were operative in the selection of the questionnaire method for data collection:

1. Cost is lower
2. Respondents are more frank
3. Interviewer bias is avoided
4. Respondents can answer at their leisure
5. Areas not specified can be added
6. Time is provided for reflection for complex questionnaires (10)

The telephone was used to select the audit experts, to resolve questions on the survey instrument, to obtain responses for incomplete questionnaires, and to follow up as required.

The Survey Instrument Organization

The survey instrument for each phase included a cover letter, directions, audit scope, characteristics computer installation, evaluation scale, and the questionnaire. Different colored paper was used to facilitate reference to the audit scope, model computer installation and evaluation scale. The only difference between the materials provided to the internal and external auditors was the audit scope, group statistics, and shared rationale. The survey letter and directions for Phases I, II, and III are provided in Appendices E, F, and G. A detached copy of the evaluation scale and characteristic computer installation characteristic was also provided to facilitate reference. The internal audit survey results for Phases I, II, and III are provided in Appendices H, I, and J. The external audit survey results are provided in Appendices K, L, and M. The audit scopes promulgated by the IIA and AICPA were used by the experts. This was particularly important for the internal audit survey since the audit scope and responsibility for internal audit staffs are determined by their respective corporate management and therefore vary from firm to firm. The experts were instructed to use the given audit scopes in conjunction with the hypothesized computer installation characteristics as the basis for judging the importance of the data processing knowledge areas and items in the questionnaire.

The Survey Instrument Evaluation Scale

According to Miller, the general guide on question scales is to use an existing scale if it has validity, reliability, and utility (11). Linstone and Turoff provide a Likert type importance scale that has been used with success in other Delphi studies. It uses the appearance of equal intervals to minimize scale errors. The scale is provided in Fig. 8, with the scale definition modified slightly to relate it directly to auditor data processing knowledge requirements (12).

Scale Reference	Definition
1. Very Important	This knowledge is essential. Must be thoroughly understood and applied. First order of priority.
2. Important	This knowledge is relevant. Must be sufficiently understood to apply. Second order of priority.
3. Moderately Important	This knowledge is usually relevant A general knowledge is acceptable Third order of priority.
4. Unimportant	Should be familiar with area. Seldom relevant. Last order of priority.
5. Most Unimportant	Knowledge desirable but not required. Rarely relevant. No priority.
6. Not Relevant	Should be dropped from consideration.

Fig. 8. Questionnaire Scale and Definition.

Analysis of the Survey Results

The analysis of the survey results addressed three major areas. The first was a comparative analysis of the results of the three phases of the Delphi process. The second was the construction of the internal, external, and composite audit knowledge profiles. The third concerned the analysis of differences between the internal and external audit populations.

The Delphi concept was developed as a result of an Air Force sponsored Rand Corporation study in the early 1950s. The objective of the study was to "obtain the most reliable consensus of opinion of a group of experts . . . by a series of intensive questionnaires interspersed with controlled opinion feedback" (13). The process was developed due to the unreliability experienced with the responses to single-phased surveys. According to the theory, each succeeding stage of the survey process should provide a more considered judgment because of the time for reflection and feedback. Each succeeding phase should also result in more consensus among the experts. Three phases were selected because experience from other Delphi studies has established that movement toward consensus falls off sharply after three iterations. In statistical terms this tendency toward consensus should be reflected in less variance from the mean. The researcher decided that it would be useful to measure the movement toward consensus. Since no statistical test could be identified to measure the changes in variance for related samples, the number of questions were counted for which there was a reduction in variance based on the standard deviation. A simple percentage was computed and used to compare the three phases. Since the samples are drawn from the same populations, it was assumed that changes in variances would be equally as likely to increase or decrease, if there was no tendency toward consensus. A sign test was then used with a ninety-five percent level of significance to measure more clearly the reduction in variance. The number of decreasing standard deviations was used for the computation. Only the major questions were used since the sign test requires question independence.

The second type of analysis concerned the construction of the internal audit, external audit, and composite data processing knowledge requirements profile. The knowledge areas and items that compose the profiles are the same as those constituting the Phase I, II, and III surveys. No items were added during Phase I, the open-ended portion of the survey. Two criteria were used to construct the profiles. The group mean was used as the measure of importance for each knowledge area or items for which the group reached consensus. Consensus was defined as "the condition when all members of the group evaluated the knowledge area or item within a range of two on the survey scale." The mean less the standard deviation or lowest level of importance assigned by a group member (whichever was higher) was used for the items for which the group did not reach consensus. The composite profile was constructed by using the highest level of importance assigned by either group. This analysis provided the answers to subsidiary research questions one and two.

The third type of survey analysis addresses subsidiary research question number three, difference between the internal and external audit data processing knowledge requirements. A multivariate analysis of variance (MANOVA) was used to determine if the audit populations were significantly different based on the major knowledge area questions. The MANOVA was used even though the data were generated from selected samples, the sample sizes were small, and the experts used a

Likert scale to make their judgments. The tests provided an analysis of population differences that was not available through non-parametric tests. The Wilcoxon two-sample test was used to determine where the populations were different and the magnitude of the differences. The ninety-five percent level of significance was also used for this analysis. The Statistical Analysis System programs were used for the MANOVA and Wilcoxon tests (14).

Comparative Review of Five Year Accounting Programs

The final phase of the study consisted of an analysis of seven five year professional accounting curricula with respect to the data processing knowledge requirements established by this study (subsidiary research question number four). The American Assembly of Collegiate Schools of Business provided a list of all members of their Accreditation Council, and the AICPA provided a list of schools that offer a five year program of accountancy. Letters were sent to each of the seventeen schools that were accredited at the masters level and had a five-year program. The curricula of the seven responding schools were then reviewed for the coverage given to the data processing knowledge requirements.

CHAPTER III: ENDNOTES

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11. Ibid., p. 86.

12. Linstone and Turoff (Editors), The Delphi Method, Turoff, The Policy Delphi, p. 91.

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CHAPTER IV

THE ANALYSIS OF SURVEY RESULTS

Introduction

This chapter contains an analysis of the results of the Delphi survey process. The discussion of the survey results falls logically into four areas: the qualifications of the experts, the results of the three survey phases, the construction of the knowledge profiles, and the analysis of differences between the final internal and external auditor responses.

Qualifications of the Internal and External Audit Experts

The qualifications of the survey participants are critical in a Delphi study or any normative study that has the objective of establishing professional knowledge requirements. The credibility of the study results is substantially dependent upon the education and experience of the study participants. The writer was fortunate in obtaining the cooperation of a group of internal and external auditors who were knowledgeable and experienced in the areas of auditing and data processing. Their audit experience was predominantly EDP audit, and their data processing experience was predominantly in the areas of programming and systems development. Most members of both groups had baccalaureate degrees and about half of each group had masters degrees. A summary of their education and experiences is provided in Figs. 8 and 9. The experts and their firms are listed in Appendices C and D.

The Survey Process

The three phase survey process took five months to complete. The audit experts were very cooperative and constructive throughout the study. Their interest is evidenced by the high number of participants completing all three phases. Eighteen surveys were sent out to begin Phase I. After as many as ten responses were received, the surveys for the next phase were prepared and mailed. This practice was necessary in order to complete the surveys in a reasonable length of time. It was also believed that the further extension of the study would decrease the benefits of using the Delphi technique due to loss of continuity

1. Average years of audit experience.

   Audit 7.5 EDP Audit 4.5 Audit Management 4.0

2. Average years of data processing experience.

   DP operations 0.7 Programming 1.7

   System Development 4.0 DP Management 1.0

3. Average Number of college courses taken.

   Introductory DP 1.1 Advanced DP 0.7

   Programming 1.6 Data Base Management System 0.1

   Distributed Processing 0.2 Communications 0.1

   System Development 0.6 Audit 0.5

   EDP Audit 0.4

4. Average number of related professional, technical, seminar, and conference courses taken.

   Introductory DP 1.1 Advanced DP 2.0

   Programming 3.3 Data Base Management System 1.3

   Distributed Processing 1.2 Communications 0.8

   System Development 1.8 Audit 2.2

   EDP Audit 3.6

5. Professional attainment (percentage of group).

   CDP 18% CISA 59% CPA 24% CIA 23%

6. Baccalaureate and Masters degrees (percentage of group)

   Bachelors degree 94% Masters degree 53%

Fig. 9. Education and Experience of Internal Audit Experts

1. Average years of audit experience.

   Audit 9.5 EDP Audit 6.9 Audit Management 3.4

2. Average years of data processing experience.

   DP operations 0.5 Programming 2.0

   System Development 2.2 DP Management 4.5

3. Average Number of college courses taken.

   Introductory DP 0.5 Advanced DP 0.8

   Programming 0.9 Data Base Management System 0.1

   Distributed Processing 0.1 Communications 0.1

   System Development 0.3 Audit 1.2

   EDP Audit 0.1

4. Average number of related professional, technical, seminar, and conference courses taken.

   Introductory DP 0.7 Advanced DP 2.5

   Programming 2.9 Data Base Management System 1.0

   Distributed Processing 0.7 Communications 1.0

   System Development 1.3 Audit 6.1

   EDP Audit 3.7

5. Professional Attainment (percentage of group).

   CDP 20% CISA 67% CPA 67% CIA 10%

6. Baccalaureate and Masters degrees (percentage of group)

   Bachelors degree 93% Masters degree 33%

Fig.10. Education and Experience of External Audit Experts

caused by the long delays between the phases. The number and the percentages of responses received for each phase are provided in Fig. 11 for each audit group. One Phase II external audit survey was lost in the mail.

Survey Phases	I	II	III
Internal Audit	17/94%	15/83%	15/83%
External Audit*	13/72%	14/78%	14/78%

Fig. 11 The Number and Percentage of Survey Responses Received (N=18) *NOTE: One list in mail.

The Delphi process was designed to facilitate consensus among a group of experts who are dealing with a complex problem. The researcher, therefore, believed it appropriate to evaluate the application of this research methodology to this study. If the Delphi process worked as expected, the responses from phase to phase would move toward consensus. The variance for responses to individual knowledge areas and items would become smaller. If the Delphi process did not work as anticipated, one would expect the changes in variance for individual responses to be approximately equally divided between increases and decreases since they are from the same population. The remaining question was at what point does decreasing variance for individual questions become significant. No statistical tests could be identified that were developed to measure differences in related, selected samples. The survey results greatly simplified the measurement problem because the movement toward consensus was substantial. Fig. 12 provides a phase-by-phase analysis of this phenomenon in terms of the number and percentage of the 295 responses for which the variance became smaller. Using the sign test, the level of significance exceeded ninety-nine percent for both audit groups.

Survey Phases	I-II	II-III	I-III
Internal Audit	261/88.5%	205/69.5%	271/91.9%
External Audit	269/91.2%	211/71.5%	283/95.9%

Fig. 12. The Number and Percentage of Survey Responses for Which the Variance Became Smaller (N=295)

The Analysis of the Survey Results

The analysis of the survey results is first directed at the construction of the data processing knowledge profiles for internal and external auditors. Second, the analysis addresses the construction of a composite profile for both internal and external auditors.

The construction of the internal audit and external audit profiles was based on the means of the responses where the respective group reached consensus. Consensus was defined as the condition where all individual responses fell within a range of two, based on the questionnaire, evaluation scale (Fig. 8). In cases where the group did not reach consensus, the group mean was lowered by one standard deviation in level of importance. The profiles should therefore be considered conservative estimates of the data processing requirements of internal and external auditors. Fig. 13 provides a summary of the levels of consensus reached for each audit group. The researcher did not hypothesize the level of consensus that the two audit groups would reach, but did expect a greater difference. It was anticipated that the broader responsibilities of internal auditors and the unique industry data processing requirements would make consensus more difficult to achieve, hence arriving at a lower level of consensus.

Group	Number/Percentage
Internal Audit	242/82%
External Audit	253/86%

Fig. 13. The Number of Questions for Which Consensus was Reached (N=295)

The construction of the composite profile differed from the construction of the profiles for the internal and external auditors. The highest level of importance assigned to either the internal or external auditor profile was used. The profiles are provided on the following pages in a comparative context. The evaluation scale used in the surveys applies. A value of one indicates that the knowledge is essential and a value of six indicates that the knowledge is not relevant. The descriptions of some knowledge items necessarily have been abbreviated. The full descriptions are provided in Appendix E. The bar graphs have been constructed with "I's" to represent the required level of data processing knowledge for internal audit, with "E's" to represent external audit knowledge requirements, and with "C's" to represent the composite profile.

The Internal, External, and Composite Data Processing Knowledge Profiles

Item Description	Internal/External/Composite Profile	Level of Importance (6 5 4 3 2 1, more important →)
Area I: Hardware	I	2.4
	E	2.7
	C	2.4
1. Major types of computers	I	2.9
	E	2.9
	C	2.9
A. Analog	I	4.4
	E	4.4
	C	4.4
B. Digital	I	2.9
	E	4.2
	C	2.9
2. Major types of digital computers	I	2.3
	E	2.4
	C	2.3
A. Micro	I	3.5
	E	3.1
	C	3.1
B. Mini	I	2.2
	E	2.4
	C	2.2
C. Conventional	I	2.2
	E	2.4
	C	2.2
3. Different computer configurations	I	1.9
	E	2.3
	C	1.9
A. Stand alone No remote I/O	I	2.3
	E	2.1
	C	2.1

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----------------------------------------------------------------------
    B. Central--     |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  1.8
       remote        |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE  2.2
       on-line I/O   |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  1.8
----------------------------------------------------------------------
    C. Distributed   |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  1.8
       networks      |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE  2.2
                     |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  1.8
----------------------------------------------------------------------
4.  Types of         |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  2.7
    operating        |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEE  3.0
    systems          |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  2.7
----------------------------------------------------------------------
    A. No O/S--      |IIIIIIIIIIIIIIIIII  4.2
       operator      |EEEEEEEEEEEEEEE  4.5
       controlled    |CCCCCCCCCCCCCCCCCC  4.2
----------------------------------------------------------------------
    B. Sequentially  |IIIIIIIIIIIIIIIIIIIIIIIII  3.5
       scheduled     |EEEEEEEEEEEEEEEEEEEEEEEEEEEEE  3.1
                     |CCCCCCCCCCCCCCCCCCCCCCCCCCCCC  3.1
----------------------------------------------------------------------
    C. Multi-        |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  2.3
       programming   |EEEEEEEEEEEEEEEEEEEEEEEEEEEEE  3.1
                     |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  2.3
----------------------------------------------------------------------
    D. Multi-        |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  2.2
       processing    |EEEEEEEEEEEEEEEEEEEEEEEEEEEEE  3.1
                     |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  2.2
----------------------------------------------------------------------
                     |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  2.1
    E. Virtual       |EEEEEEEEEEEEEEEEEEEEEEEEEEEE  3.2
                     |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  2.1
----------------------------------------------------------------------
                     |IIIIIIIIIII  4.9
    F. Emulation     |EEEEEEEEEEEEEEEEEEEEE  3.9
                     |CCCCCCCCCCCCCCCCCCCCC  3.9
----------------------------------------------------------------------
5.  Storage          |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  2.6
    mediums in use   |EEEEEEEEEEEEEEEEEEEEEEEEEEEEE  3.1
                     |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  2.6
----------------------------------------------------------------------
    A. Primary       |IIIIIIIIIIIIIIIIIIIIIIIIIIIIII  3.0
       memory        |EEEEEEEEEEEEEEEEEEEEE  3.9
       (types)       |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  3.0
----------------------------------------------------------------------
    B. Secondary     |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  2.5
       memory        |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE  2.9
       (types)       |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  2.5
----------------------------------------------------------------------
6.  I/O and          |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  2.5
    storage          |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE  2.9
    devices          |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  2.5
----------------------------------------------------------------------
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------------------------------------------------------------------------
               |IIIIIIIIIIIIIIIIIIIIIIIIIIII  3.2         |          |
A. Printers    |EEEEEEEEEEEEEEEEEEEEEEEEEEE  3.3          |          |
               |CCCCCCCCCCCCCCCCCCCCCCCCCCCC  3.2         |          |
------------------------------------------------------------------------
               |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  2.8     |          |
B. Tape drives |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEE  3.0       |          |
               |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  2.8     |          |
------------------------------------------------------------------------
               |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  2.8     |          |
C. Disk drives |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEE  3.0       |          |
               |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  2.8     |          |
------------------------------------------------------------------------
D. Mass        |IIIIIIIIIIIIIIIIIIIIIIIIIIIIII  3.0       |          |
   storage     |EEEEEEEEEEEEEEEEEEEEEEEEEEE  3.3          |          |
   units       |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  3.0       |          |
------------------------------------------------------------------------
E. Readers--   |IIIIIIIIIIIIIIIIIIIIIIIIIIIII  3.1        |          |
   card, MICR, |EEEEEEEEEEEEEEEEEEEEEEEEEEE  3.3          |          |
   OCR. . .    |CCCCCCCCCCCCCCCCCCCCCCCCCCCCC  3.1        |          |
------------------------------------------------------------------------
F. Card        |IIIIIIIIIIIIIIIIIIII  4.0       |         |          |
   punches     |EEEEEEEEEEE  4.9                |         |          |
               |CCCCCCCCCCCCCCCCCCCC  4.0       |         |          |
------------------------------------------------------------------------
G. Intelligent |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  2.1          |
   terminals   |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE  2.6               |
               |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  2.1           |
------------------------------------------------------------------------
               |IIIIIIIIIIIIIIIIIIIIIIIIII  3.4           |          |
H. Microfilm   |EEEEEEEEEE  5.0                           |          |
               |CCCCCCCCCCCCCCCCCCCCCCCCCC  3.4           |          |
------------------------------------------------------------------------
               |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  2.6              |
I. CRTs        |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE  2.6              |
               |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  2.6              |
------------------------------------------------------------------------
               |IIIIIIIIIIIIIIIIIIIIIIIIIIII  3.2         |          |
J. Keyboards   |EEEEEEEEEEEEEEEEEEEEEEE  3.7              |          |
               |CCCCCCCCCCCCCCCCCCCCCCCCCCCC  3.2         |          |
------------------------------------------------------------------------
K. Point-of-   |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  2.5             |
   sale        |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEE  3.0                  |
               |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  2.5             |
------------------------------------------------------------------------
               |IIIIIIIIII  5.0    |          |           |          |
L. Audio       |EEEEEEEE  5.2      |          |           |          |
               |CCCCCCCCCC  5.0    |          |           |          |
------------------------------------------------------------------------
               |IIIIIIIIIIIII  4.7            |           |          |
M. Converters  |EEEEEEEEEEEEEEEEEE  4.2       |           |          |
               |CCCCCCCCCCCCCCCCCC  4.2       |           |          |
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                   |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  2.1       |
7.  Communications |EEEEEEEEEEEEEEEEEEEEEEEEEEEE  3.2                  |
                   |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  2.1       |
-----------------------------------------------------------------------|
    A. Modems/     |IIIIIIIIIIIIIIIIIIIIIIII  3.6|          |          |
       data sets   |EEEEEEEEEEEEEEEEEEEEEEE  3.7 |          |          |
                   |CCCCCCCCCCCCCCCCCCCCCCCC  3.6|          |          |
-----------------------------------------------------------------------|
    B. Line        |IIIIIIIIIIIIIIIIIIIIIII  3.7 |          |          |
       controllers |EEEEEEEEEEEEEEEEEE  4.2      |          |          |
                   |CCCCCCCCCCCCCCCCCCCCCCC  3.7 |          |          |
-----------------------------------------------------------------------|
    C. Multiplexers|IIIIIIIIIIIIIIIIIIIII  3.9   |          |          |
       selector    |EEEEEEEEEEEEEEEEEE  4.2      |          |          |
       channels    |CCCCCCCCCCCCCCCCCCCCC  3.9   |          |          |
-----------------------------------------------------------------------|
    D. Concen-     |IIIIIIIIIIIIIIIIIIII  4.0    |          |          |
       trators     |EEEEEEEEEEEEEEEEEE  4.2      |          |          |
                   |CCCCCCCCCCCCCCCCCCCC  4.0    |          |          |
-----------------------------------------------------------------------|
    E. Types of    |IIIIIIIIIIIIIIIIIIIII  3.9   |          |          |
       channels    |EEEEEEEEEEEEEEEEEE  4.2      |          |          |
                   |CCCCCCCCCCCCCCCCCCCCC  3.9   |          |          |
-----------------------------------------------------------------------|
    F. Front-end   |IIIIIIIIIIIIIIIIIIIIIIII  3.6|          |          |
       processors  |EEEEEEEEEEEEEEEEEEEE  4.0    |          |          |
                   |CCCCCCCCCCCCCCCCCCCCCCCG  3.6|          |          |
-----------------------------------------------------------------------|
    G. Crypto-     |IIIIIIIIIIIIIIIIIIIIIIII  3.6|          |          |
       graphic     |EEEEEEEEEE  5.0              |          |          |
       devices     |CCCCCCCCCCCCCCCCCCCCCCCC  3.6|          |          |
-----------------------------------------------------------------------|
8.  Hardware       |IIIIIIIIIIIIIIIIIIIIIIIII  3.5          |          |
    related code   |EEEEEEEEEEEEEEEEEEEEEEEEEEE  3.3        |          |
    structures     |CCCCCCCCCCCCCCCCCCCCCCCCCCC  3.3        |          |
-----------------------------------------------------------------------|
                   |IIIIIIIIIIIIII  4.6          |          |          |
    A. Hollerith   |EEEEEEEEEE  5.0              |          |          |
                   |CCCCCCCCCCCCCC  4.6          |          |          |
-----------------------------------------------------------------------|
                   |IIIIIIIIIIIIIIIIIIIIII  3.8             |          |
    B. ASCII codes |EEEEEEEEEEEEEEEEEEEEEEEEEEEE  3.2       |          |
                   |CCCCCCCCCCCCCCCCCCCCCCCCCCCC  3.2       |          |
-----------------------------------------------------------------------|
                   |IIIIIIIIIIIIIIIIIIIIIIIII  3.5          |          |
    C. EBCDIC      |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEE  3.0     |          |
                   |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  3.0     |          |
-----------------------------------------------------------------------|
    D. Binary      |IIIIIIIIIIIIIIIIIIII  4.0    |          |          |
       coded       |EEEEEEEEEEEEEEEEEEEEE  3.9   |          |          |
       decimal     |CCCCCCCCCCCCCCCCCCCCC  3.9   |          |          |
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E. BAR codes	IIIIIIIIIII 4.9
	EEEEEEEEEE 5.0
	CCCCCCCCCCC 4.9
9. Punched card accounting equipment	IIIIIIIIIIIIIIIIIIII 4.0
	EEEEEEEEEEEEEEEEEEEE 4.0
	CCCCCCCCCCCCCCCCCCCC 4.0
A. Keypunch	IIIIIIIIIIIIIIIIIIIIIIIII 3.5
	EEEEEEEEEEEEEEEEEEEE 4.0
	CCCCCCCCCCCCCCCCCCCCCCCCC 3.5
B. Verifier	IIIIIIIIIIIIIIIIIIIIIIIII 3.5
	EEEEEEEEEEEEEEEEEEEE 4.0
	CCCCCCCCCCCCCCCCCCCCCCCCC 3.5
C. Sorter	IIIIIIIIIIIIIIIIIIIIIIII 3.6
	EEEEEEEEEEEEEEEEEEE 4.1
	CCCCCCCCCCCCCCCCCCCCCCCC 3.6
D. Interpreter	IIIIIIIIIIIIIII 4.5
	EEEEEEEEEEEEEEEEEEE 4.1
	CCCCCCCCCCCCCCCCCCC 4.1
E. Reproducing punch	IIIIIIIIIIII 4.8
	EEEEEEEEEEEEEEEEEEE 4.1
	CCCCCCCCCCCCCCCCCCC 4.1
10. Hardware related techniques	IIIIIIIIIIIIIIIIIIIIIIIIIIII 3.2
	EEEEEEEEEEEEEEEEEEEEE 3.9
	CCCCCCCCCCCCCCCCCCCCCCCCCCCC 3.2
A. Parity	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.8
	EEEEEEEEEEEEEEEEEEEEEEE 3.7
	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.8
B. Buffering	IIIIIIIIIIIIIIIIIIIIIIIIIII 3.3
	EEEEEEEEEEEEEEEEEEEE 4.0
	CCCCCCCCCCCCCCCCCCCCCCCCCCC 3.3
C. Modularity	IIIIIIIIIIIIIIIIIIIIIIIIIII 3.3
	EEEEEEEEEEEEEEEEEEE 4.1
	CCCCCCCCCCCCCCCCCCCCCCCCCCC 3.3
D. Protocols	IIIIIIIIIIIIIIIIIIIIIIIIII 3.4
	EEEEEEEEEEEEEEEEEEEE 4.0
	CCCCCCCCCCCCCCCCCCCCCCCCCC 3.4
E. Acknowledgement	IIIIIIIIIIIIIIIIIIIIIIIIIIIII 3.1
	EEEEEEEE 5.2
	CCCCCCCCCCCCCCCCCCCCCCCCCCCCC 3.1

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----------------------------------------------------------------------
   F. Packet       |IIIIIIIIIIIIIIIIIIIIIIIIII  3.4          |         |
      switching    |EEEEEEEE  5.2                            |         |
                   |CCCCCCCCCCCCCCCCCCCCCCCCCC  3.4          |         |
----------------------------------------------------------------------|
11. Specialized    |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  2.6             |
    systems        |EEEEEEEEEEEEEEEEEEEEEEEEEEEE  3.2                   |
                   |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  2.6             |
----------------------------------------------------------------------|
                   |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  2.4           |
   A. Data entry   |EEEEEEEEEEEEEEEEEEEEEEEEEEEEE  3.1                  |
                   |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  2.4           |
----------------------------------------------------------------------|
   B. Word         |IIIIIIIIIIIIIIIIIII  4.1    |          |          |
      processing   |EEEEEEEEEEEE  4.8           |          |          |
                   |CCCCCCCCCCCCCCCCCCC  4.1    |          |          |
----------------------------------------------------------------------|
12. The operation  |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  2.0       |
    of components  |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE  2.7              |
    as a system    |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  2.0       |
----------------------------------------------------------------------|
   A. Data         |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  2.0       |
      transmission|EEEEEEEEEEEEEEEEEEEEEEEEEEEEEE  3.0                  |
                   |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  2.0       |
----------------------------------------------------------------------|
   B. Data         |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  1.8     |
      control      |EEEEEEEEEEEEEEEEEEEEEEEEEE  3.4                     |
                   |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  1.8     |
----------------------------------------------------------------------|
   C. Data         |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  1.9      |
      manipula-    |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE  2.7              |
      tion         |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  1.9      |
----------------------------------------------------------------------|
13. Security and   |IIIIIIIIIIIIIIIIIIIIII 1.1 IIIIIIIIIIIIIIIIIIIIII|
    control        |EEEEEEEEEEEEEEEEEEEEEE 1.6 EEEEEEEEEEEEEEEEE     |
    features       |CCCCCCCCCCCCCCCCCCCCCC 1.1 CCCCCCCCCCCCCCCCCCCCCC|
----------------------------------------------------------------------


----------------------------------------------------------------------
                   |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  2.0       |
AREA II:  Software |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE  2.2         |
                   |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  2.0       |
----------------------------------------------------------------------|
1.  Available      |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  1.9      |
    languages      |EEEEEEEEEEEEEEEEEEEEEEEEEE  3.4                     |
                   |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  1.9      |
----------------------------------------------------------------------|
                   |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  1.9      |
   A. High level   |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEE  3.0                 |
                   |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  1.9      |
----------------------------------------------------------------------
```

B. Data base management system	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.0
	EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.6
	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.0
C. Specialized inquiry/rpt. generation	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 1.9
	EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.8
	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 1.9
D. Special purpose	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.5
	EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.8
	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.5
E. Modeling/ simulation	IIIIIIIIIIIIIIIIIIII 4.0
	EEEEEEEEEEEEEEEEEEE 4.1
	CCCCCCCCCCCCCCCCCCCC 4.0
2. Language classifications	IIIIIIIIIIIIIIIIIIII 4.0
	EEEEEEEEEEEEEEEEEE 4.2
	CCCCCCCCCCCCCCCCCCCC 4.0
A. Machine/ PAL/HLL/ natural	IIIIIIIIIIIIII 4.6
	EEEEEEEEEEEEEEEEEE 4.2
	CCCCCCCCCCCCCCCCCC 4.2
B. Procedural/ non-procedural	IIIIIIIIIIIIIIIIIIII 4.0
	EEEEEEEEEEEEEEEEEE 4.2
	CCCCCCCCCCCCCCCCCCCC 4.0
3. Types of programs	IIIIIIIIIIIIIIIIIIIIII 1.7 IIIIIIIIIIIIIIII
	EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.0
	CCCCCCCCCCCCCCCCCCCCCC 1.7 CCCCCCCCCCCCCCCC
A. Application	IIIIIIIIIIIIIIIIIIIIII 1.4 IIIIIIIIIIIIIIIIIII
	EEEEEEEEEEEEEEEEEEEEEE 1.6 EEEEEEEEEEEEEEEEE
	CCCCCCCCCCCCCCCCCCCCCC 1.4 CCCCCCCCCCCCCCCCCCC
B. Utility	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 1.9
	EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.8
	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 1.9
C. Operating system	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.1
	EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.6
	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.1
D. Translator	IIIIIIIIIIIIIIIIIIIII 3.9
	EEEEEEEEEEEEEEEEEEEEE 3.9
	CCCCCCCCCCCCCCCCCCCCC 3.9
4. Understand software interfaces	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 1.8
	EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.1
	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 1.8

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    A. Application |IIIIIIIIIIIIIIIIIIIIII 1.6 IIIIIIIIIIIIIIIII       |
       programs    |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE  2.0     |
                   |CCCCCCCCCCCCCCCCCCCCCC 1.6 CCCCCCCCCCCCCCCCC       |
-----------------------------------------------------------------------|
                   |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  2.0     |
    B. DBMS        |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE  2.2       |
                   |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  2.0     |
-----------------------------------------------------------------------|
    C. Distributed |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  2.0     |
       systems     |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE  2.1      |
                   |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  2.0     |
-----------------------------------------------------------------------|
    D. Electronic  |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  2.6           |
       funds trans-|EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE  2.0     |
       fer system  |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  2.0     |
-----------------------------------------------------------------------|
    E. Electronic  |IIIIIIIIIIIIIIIIIIIIIIIIIIII  3.3         |         |
       mail        |EEEEEEEEEEEEE  4.7                        |         |
       systems     |CCCCCCCCCCCCCCCCCCCCCCCCCCCC  3.3         |         |
-----------------------------------------------------------------------|
5.  Understand     |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  2.5          |
    programming    |EEEEEEEEEEEEEEEEEEEEEEEEE  3.6                     |
    techniques     |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  2.5          |
-----------------------------------------------------------------------|
6.  Operation of   |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  2.2       |
    major types of |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEE  3.1                |
    DBMS systems   |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  2.2       |
-----------------------------------------------------------------------|
    A. Modification|IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  2.3        |
       of operating|EEEEEEEEEEEEEEEEEEEEEEEEEEEEEE  3.1                |
       system (OS) |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  2.3        |
-----------------------------------------------------------------------|
    B. Interfaces  |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  2.5          |
       with exist- |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEE  3.1                |
       ing OS      |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  2.5          |
-----------------------------------------------------------------------|
    C. Used with   |IIIIIIIIIIIIIIIIIIIIIIIII  3.5            |         |
       back-end    |EEEEEEEEEEEEEEEEEEEEEEEE  3.6             |         |
       processor   |CCCCCCCCCCCCCCCCCCCCCCCCC  3.5            |         |
-----------------------------------------------------------------------|
7.  Structure of   |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  2.6           |
    software       |EEEEEEEEEEEEEEEEEEEEEE  3.8                        |
                   |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  2.6           |
-----------------------------------------------------------------------|
    A. System      |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  2.6           |
       architecture|EEEEEEEEEEEEEEEEEEEEE  3.9                         |
                   |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  2.6           |
-----------------------------------------------------------------------|
    B. Instruction |IIIIIIIIIIIIIIIIIIIIIIIII  3.5            |         |
       formats     |EEEEEEEEEEEEEEEEEEEE  4.0                 |         |
                   |CCCCCCCCCCCCCCCCCCCCCCCCC  3.5            |         |
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    C. Program      |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  2.7 |          |
       construction |EEEEEEEEEEEEEEEEEEEEE  3.9             |          |
                    |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  2.7 |          |
------------------------------------------------------------------------
    D. Translator   |IIIIIIIIIIII  4.8          |           |          |
       construction |EEEEEEEEEEEEEEEEEEE  4.1   |           |          |
                    |CCCCCCCCCCCCCCCCCCC  4.1   |           |          |
------------------------------------------------------------------------
    E. Operating    |IIIIIIIIIIIIIIIIIIIIIIIIIIIIII  3.0    |          |
       system       |EEEEEEEEEEEEEEEEEEEE  4.0              |          |
       structure    |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  3.0    |          |
------------------------------------------------------------------------
8.  Software        |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  2.6           |
    evaluation      |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE  2.9              |
    techniques      |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  2.6           |
------------------------------------------------------------------------
9.  Software        |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  2.9   |          |
    trends          |EEEEEEEEEEEEEEEEEEEEEEEE  3.6          |          |
                    |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  2.9   |          |
------------------------------------------------------------------------
10. Available       |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  2.9   |          |
    packaged        |EEEEEEEEEEEEEEEEEEEEEEEEEEE  3.3       |          |
    software        |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  2.9   |          |
------------------------------------------------------------------------
                    |IIIIIIIIIIIIIIIIIIIIIIIIIIIIII  3.0    |          |
    A. Vendors      |EEEEEEEEEEEEEEEEEEEEEEEEEEEE  3.2      |          |
                    |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  3.0    |          |
------------------------------------------------------------------------
                    |IIIIIIIIIIIIIIIIIIIIIIIIIIIIII  3.0    |          |
    B. User groups  |EEEEEEEEEEEEEEEEEEEEEEEEEEE  3.3       |          |
                    |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  3.0    |          |
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AREA III:  Systems  |IIIIIIIIIIIIIIIIIIIIII 1.5 IIIIIIIIIIIIIIIIII     |
          Analysis  |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE  2.3        |
          & Design  |CCCCCCCCCCCCCCCCCCCCCC 1.5 CCCCCCCCCCCCCCCCCC     |
------------------------------------------------------------------------
1.  Systems         |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  2.0     |
    development     |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEE  3.0               |
    methodologies   |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  2.0     |
------------------------------------------------------------------------
2.  Systems study   |IIIIIIIIIIIIIIIIIIIIII 1.7 IIIIIIIIIIIIIIII       |
    study           |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE  2.3        |
    procedures      |CCCCCCCCCCCCCCCCCCCCCC 1.7 CCCCCCCCCCCCCCCC       |
------------------------------------------------------------------------
    A. Project      |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  1.8   |
       origination  |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE  2.2       |
       and approval |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  1.8   |
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    B. Problem      |IIIIIIIIIIIIIIIIIIIIII 1.5 IIIIIIIIIIIIIIIII   |
       definition/  |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE  2.2    |
       documentatn. |CCCCCCCCCCCCCCCCCCCCCC 1.5 CCCCCCCCCCCCCCCCC   |
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    C. Feasibility  |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  1.9  |
       study        |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE  2.8          |
                    |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  1.9  |
------------------------------------------------------------------------|
    D. Systems      |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  1.8 |
       study        |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE  2.6        |
                    |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  1.8 |
------------------------------------------------------------------------|
    E. Systems      |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  1.8 |
       development  |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE  2.3     |
                    |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  1.8 |
------------------------------------------------------------------------|
    F. Systems      |IIIIIIIIIIIIIIIIIIIIII 1.4 IIIIIIIIIIIIIIIIII  |
       testing      |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE  2.1   |
                    |CCCCCCCCCCCCCCCCCCCCCC 1.4 CCCCCCCCCCCCCCCCCC  |
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    G. Systems      |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  1.8 |
       implementa-  |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE  2.3     |
       tion methods |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  1.8 |
------------------------------------------------------------------------|
    H. Conversion   |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  1.9  |
       techniques   |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE  2.3     |
                    |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  1.9  |
------------------------------------------------------------------------|
    I. Systems/     |IIIIIIIIIIIIIIIIIIIIII 1.5 IIIIIIIIIIIIIIIII   |
       program      |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE  2.2    |
       maintenance  |CCCCCCCCCCCCCCCCCCCCCC 1.5 CCCCCCCCCCCCCCCCC   |
------------------------------------------------------------------------|
3.  Ability to      |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  2.2     |
    design a        |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEE  3.0             |
    simple system   |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  2.2     |
------------------------------------------------------------------------|
                    |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  2.3      |
    A. Batch        |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEE  3.0             |
                    |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  2.3      |
------------------------------------------------------------------------|
    B. On-line--    |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  2.3      |
       few          |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEE  3.0             |
       interfaces   |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  2.3      |
------------------------------------------------------------------------|
4.  Programming     |IIIIIIIIIIIIIIIIIIIIII 1.6 IIIIIIIIIIIIIIII    |
    process         |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE  2.0  |
                    |CCCCCCCCCCCCCCCCCCCCCC 1.6 CCCCCCCCCCCCCCCC    |
------------------------------------------------------------------------|
5.  Able to         |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  2.2     |
    program         |EEEEEEEEEEEEEEEEEEEE  4.0                       |
                    |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  2.2     |
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A. Program assembly language	IIIIIIIIIIIII 4.7 EEEEEE 5.4 CCCCCCCCCCCCC 4.7
B. High level language	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.2 EEEEEEEEEEEEEEEEEEEE 4.0 CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.2
C. DBMS language	IIIIIIIIIIIIIIIIIIIIIIIIIIIIII 3.0 EEEEEEEEEEEEEEEEEEEEEE 3.8 CCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 3.0
D. Modeling/ mathematical language	IIIIIIIIII 5.0 EEEEEEEEEEEEEEEE 4.4 CCCCCCCCCCCCCCCC 4.4
E. At least one language	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 1.9 EEEEEEEEEEEEEEEEEE 4.2 CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 1.9
6. Understand and evaluate the design & use of	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 1.9 EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.0 CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 1.9
A. Forms and reports	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.1 EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.1 CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.1
B. Multiple organization systems	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.0 EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.7 CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.0
C. Spec. files-indices, tables, etc.	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.0 EEEEEEEEEEEEEEEEEEEEEEE 3.7 CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.0
D. Coding systems	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.4 EEEEEEEEEEEEEEEEEEEE 4.0 CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.4
E. Multimode processing systems	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.6 EEEEEEEEEEEEEEE 4.5 CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.6
F. Recovery/ restart procedures	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 1.8 EEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 3.0 CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 1.8
G. Operating systems	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.1 EEEEEEEEEEEEEEEEEEEEEEEEEEE 3.3 CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.1

7. File	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.0
organizations	EEEEEEEEEEEEEEEEEEEEEEEEEEE 3.3
	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.0
	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.1
A. Sequential	EEEEEEEEEEEEEEEEEEEEEEEEEEE 3.3
	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.1
B. Index	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.1
sequential	EEEEEEEEEEEEEEEEEEEEEEEEEEE 3.3
	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.1
C. Random proc.	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.1
non-integra-	EEEEEEEEEEEEEEEEEEEEEEEEEEE 3.3
ted files	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.1
D. Integrated	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.0
DB—batch	EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.6
processing	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.0
E. Integrated	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 1.9
DB—real-	EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.6
time proc.	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 1.9
F. Shared	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 1.9
files	EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.7
	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 1.9
G. Special	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.1
reports	EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.8
files	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.1
H. Operating	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.2
system files	EEEEEEEEEEEEEEEEEEEEEEEEEEE 3.3
records	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.2
8. File access	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.1
techniques	EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.6
	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.1
	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.4
A. Sequential	EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.6
	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.4
B. Index	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.4
sequential	EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.6
	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.4
	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.5
C. Direct	EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.6
	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.5

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                  |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  2.6          |
   D. Indices     |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE  2.6          |
                  |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  2.6          |
------------------------------------------------------------------------|
9. Diagnostic     |IIIIIIIIIIIIIIIIIIIIIIIIIIIIII  3.0    |         |
   aids           |EEEEEEEEEEEEEEEEEEEEEE  3.8            |         |
                  |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  3.0    |         |
------------------------------------------------------------------------|
   A. Software    |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  2.9   |         |
      monitors    |EEEEEEEEEEEEEEEEEEEEEEEEEE  3.4        |         |
                  |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  2.9   |         |
------------------------------------------------------------------------|
   B. Hardware    |IIIIIIIIIIIIIIIIIIIIIIIIIIII  3.2      |         |
      monitors    |EEEEEEEEEEEEEEEEEEEEEE  3.8            |         |
                  |CCCCCCCCCCCCCCCCCCCCCCCCCCCC  3.2      |         |
------------------------------------------------------------------------|
10. Computer      |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  2.0    |
    applications  |EEEEEEEEEEEEEEEEEEEEEE 1.7 EEEEEEEEEEEEEEEE      |
                  |CCCCCCCCCCCCCCCCCCCCCC 1.7 CCCCCCCCCCCCCCCC      |
------------------------------------------------------------------------|
   A. Range of    |IIIIIIIIIIIIIIIIIIIIII 1.8 IIIIIIIIIIIIIII       |
      applications|EEEEEEEEEEEEEEEEEEEEEE 1.6 EEEEEEEEEEEEEEEEE     |
                  |CCCCCCCCCCCCCCCCCCCCCC 1.6 CCCCCCCCCCCCCCCCC     |
------------------------------------------------------------------------|
   B. Decision sup|IIIIIIIIIIIIIIIIIIIIIIII  3.6           |        |
      techniques--|EEEEEEEEEEEEEEEEEEEEE  3.9              |        |
      models/sim. |CCCCCCCCCCCCCCCCCCCCCCCC  3.6           |        |
------------------------------------------------------------------------|
   C. Specialized |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  2.7  |         |
      applications|EEEEEEEEEEEEEEEEEEEE  4.0               |         |
                  |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  2.7  |         |
------------------------------------------------------------------------|
      a. Electron.|IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  2.8   |         |
         funds    |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE  2.8   |         |
         transfer |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  2.8   |         |
------------------------------------------------------------------------|
      b. Prod.--  |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  2.5          |
         data     |EEEEEEEEEEEEEEEEE  4.3                           |
         acquis.  |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  2.5          |
------------------------------------------------------------------------|
      c. Elec-    |IIIIIIIIIIIIIIIIIIIIIIIII  3.5          |         |
         tronic   |EE  5.8                                |         |
         mail     |CCCCCCCCCCCCCCCCCCCCCCCCC  3.5          |         |
------------------------------------------------------------------------|
11. Types of      |IIIIIIIIIIIIIIIIIIIIII 1.3 IIIIIIIIIIIIIIIIIIII  |
    documentation |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE  2.2      |
                  |CCCCCCCCCCCCCCCCCCCCCC 1.3 CCCCCCCCCCCCCCCCCCCC  |
------------------------------------------------------------------------|
                  |IIIIIIIIIIIIIIIIIIIIII 1.3 IIIIIIIIIIIIIIIIIIII  |
   A. Program     |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE  2.2      |
                  |CCCCCCCCCCCCCCCCCCCCCC 1.3 CCCCCCCCCCCCCCCCCCCC  |
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B. System	IIIIIIIIIIIIIIIIIIIIII 1.2 IIIIIIIIIIIIIIIIIIIII EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.1 CCCCCCCCCCCCCCCCCCCCCC 1.2 CCCCCCCCCCCCCCCCCCCCC
C. Data processing operations	IIIIIIIIIIIIIIIIIIIIII 1.4 IIIIIIIIIIIIIIIIIII EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.2 CCCCCCCCCCCCCCCCCCCCCC 1.4 CCCCCCCCCCCCCCCCCCC
D. User	IIIIIIIIIIIIIIIIIIIIII 1.4 IIIIIIIIIIIIIIIIIII EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.1 CCCCCCCCCCCCCCCCCCCCCC 1.4 CCCCCCCCCCCCCCCCCCC
12. General categories of charts	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.3 EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.6 CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.3
A. Activity	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.5 EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.7 CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.5
B. Layout	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.3 EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.3 CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.3
C. Personal/ orgn. relationships	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.2 EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 1.8 CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 1.8
D. Statistical	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.8 EEEEEEEEEEEEEEEEEEEEEEEEEEE 3.3 CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.8
13. Specific types of charting	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 1.8 EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.3 CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 1.8
A. Program logic	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 1.9 EEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 3.0 CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 1.9
B. Hierarchical I/P/Output (HIPO)	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.0 EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.1 CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.0
C. Systems flowchart	IIIIIIIIIIIIIIIIIIIIII 1.3 IIIIIIIIIIIIIIIIIIII EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.1 CCCCCCCCCCCCCCCCCCCCCC 1.3 CCCCCCCCCCCCCCCCCCCC
D. Process flowcharts	IIIIIIIIIIIIIIIIIIIIII 1.6 IIIIIIIIIIIIIIIII EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.7 CCCCCCCCCCCCCCCCCCCCCC 1.6 CCCCCCCCCCCCCCCCC

	IIIIIIIIIIIIIIIIIII 4.1	
E. Gantt	EEEEEEEEEEE 4.9	
	CCCCCCCCCCCCCCCCCCC 4.1	
14. Solution	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.5	
alternatives	EEEEEEEEEEEEEEEEEEEEEEEEEEEEE 3.1	
	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.5	
A. Types/sizes	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.9	
of computers	EEEEEEEEEEEEEEEEEEEEEEEEEEEE 3.2	
	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.9	
B. Computer	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.9	
configura-	EEEEEEEEEEEEEEEEEEEEEEEEEEEE 3.2	
tions	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.9	
C. Software	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.6	
—in-house	EEEEEEEEEEEEEEEEEEEEEEEEEE 3.4	
contract...	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.6	
D. Special	IIIIIIIIIIIIIIIIIIIIIIIIIIIII 3.1	
services--	EEEEEEEEEEEEEEEEEEEEEEEE 3.6	
vendor	CCCCCCCCCCCCCCCCCCCCCCCCCCCCC 3.1	
E. Time sharing	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.9	
,purchase,	EEEEEEEEEEEEEEEEEEEEEEEE 3.6	
lease	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.9	
15. Control	IIIIIIIIIIIIIIIIIIIIII 1.1	IIIIIIIIIIIIIIIIIIIIII
techniques	EEEEEEEEEEEEEEEEEEEEEE 1.0	EEEEEEEEEEEEEEEEEEEEEE
	CCCCCCCCCCCCCCCCCCCCCC 1.0	CCCCCCCCCCCCCCCCCCCCCC
A. Access--fac.	IIIIIIIIIIIIIIIIIIIIII 1.1	IIIIIIIIIIIIIIIIIIIIII
hard/softw.	EEEEEEEEEEEEEEEEEEEEEE 1.2	EEEEEEEEEEEEEEEEEEEEE
and data	CCCCCCCCCCCCCCCCCCCCCC 1.1	CCCCCCCCCCCCCCCCCCCCCC
B. Input--hard-	IIIIIIIIIIIIIIIIIIIIII 1.1	IIIIIIIIIIIIIIIIIIIIII
ware, softw.	EEEEEEEEEEEEEEEEEEEEEE 1.1	EEEEEEEEEEEEEEEEEEEEEE
& procedures	CCCCCCCCCCCCCCCCCCCCCC 1.1	CCCCCCCCCCCCCCCCCCCCCC
	IIIIIIIIIIIIIIIIIIIIII 1.1	IIIIIIIIIIIIIIIIIIIIII
C. Processing	EEEEEEEEEEEEEEEEEEEEEE 1.0	EEEEEEEEEEEEEEEEEEEEEE
	CCCCCCCCCCCCCCCCCCCCCC 1.0	CCCCCCCCCCCCCCCCCCCCCC
a. Appli-	IIIIIIIIIIIIIIIIIIIIII 1.1	IIIIIIIIIIIIIIIIIIIIII
cation	EEEEEEEEEEEEEEEEEEEEEE 1.0	EEEEEEEEEEEEEEEEEEEEEE
programs	CCCCCCCCCCCCCCCCCCCCCC 1.0	CCCCCCCCCCCCCCCCCCCCCC
b. Utility	IIIIIIIIIIIIIIIIIIIIII 1.3	IIIIIIIIIIIIIIIIIIII
programs	EEEEEEEEEEEEEEEEEEEEEE 1.4	EEEEEEEEEEEEEEEEEEE
	CCCCCCCCCCCCCCCCCCCCCC 1.3	CCCCCCCCCCCCCCCCCCCC

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---------------------------------------------------------------------
     c. Operating|IIIIIIIIIIIIIIIIIIIIII 1.4 IIIIIIIIIIIIIIIIIII  |
        system   |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.1     |
                 |CCCCCCCCCCCCCCCCCCCCCC 1.4 CCCCCCCCCCCCCCCCCCC  |
-----------------------------------------------------------------|
     d. Special  |IIIIIIIIIIIIIIIIIIIIII 1.4 IIIIIIIIIIIIIIIIIII  |
        appli-   |EEEEEEEEEEEEEEEEEEEEEE 1.8 EEEEEEEEEEEEEEE      |
        cations  |CCCCCCCCCCCCCCCCCCCCCC 1.4 CCCCCCCCCCCCCCCCCCC  |
-----------------------------------------------------------------|
        (1). Time|IIIIIIIIIIIIIIIIIIIIII 1.5 IIIIIIIIIIIIIIIIII   |
        sharing--|EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.2      |
        3rd party|CCCCCCCCCCCCCCCCCCCCCC 1.5 CCCCCCCCCCCCCCCCCC   |
-----------------------------------------------------------------|
        (2). DBMS|IIIIIIIIIIIIIIIIIIIIII 1.3 IIIIIIIIIIIIIIIIIIII |
                 |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.9             |
                 |CCCCCCCCCCCCCCCCCCCCCC 1.3 CCCCCCCCCCCCCCCCCCCC |
-----------------------------------------------------------------|
        (3). Com.|IIIIIIIIIIIIIIIIIIIIII 1.4 IIIIIIIIIIIIIIIIIII  |
        networks |EEEEEEEEEEEEEEEEEEEEEEEEEE 3.4                  |
                 |CCCCCCCCCCCCCCCCCCCCCC 1.4 CCCCCCCCCCCCCCCCCCC  |
-----------------------------------------------------------------|
        (4). Err-|IIIIIIIIIIIIIIIIIIIIII 1.1 IIIIIIIIIIIIIIIIIIIIII|
        or corec-|EEEEEEEEEEEEEEEEEEEEEE 1.3 EEEEEEEEEEEEEEEEEEEE  |
        tion     |CCCCCCCCCCCCCCCCCCCCCC 1.1 CCCCCCCCCCCCCCCCCCCCCC|
-----------------------------------------------------------------|
   D. Sys. analy.|IIIIIIIIIIIIIIIIIIIIII 1.1 IIIIIIIIIIIIIIIIIIIIII|
      design, and|EEEEEEEEEEEEEEEEEEEEEE 1.4 EEEEEEEEEEEEEEEEEEE   |
      implementat.|CCCCCCCCCCCCCCCCCCCCCC 1.1 CCCCCCCCCCCCCCCCCCCCCC|
-----------------------------------------------------------------|
   E. Documenta- |IIIIIIIIIIIIIIIIIIIIII 1.1 IIIIIIIIIIIIIIIIIIIIII|
      tion       |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 1.9   |
                 |CCCCCCCCCCCCCCCCCCCCCC 1.1 CCCCCCCCCCCCCCCCCCCCCC|
-----------------------------------------------------------------|
                 |IIIIIIIIIIIIIIIIIIIIII 1.1 IIIIIIIIIIIIIIIIIIIIII|
   F. Output     |EEEEEEEEEEEEEEEEEEEEEE 1.1 EEEEEEEEEEEEEEEEEEEEEE|
                 |CCCCCCCCCCCCCCCCCCCCCC 1.1 CCCCCCCCCCCCCCCCCCCCCC|
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AREA IV: DP Opera-|IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 1.8 |
    tions         |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.1    |
    (DP & Depart.)|CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 1.8 |
-----------------------------------------------------------------|
1.  Tape management|IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.0   |
    and control   |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.0    |
                  |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.0    |
-----------------------------------------------------------------|
2.  Forms mgt. and|IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.5         |
    control       |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.4        |
                  |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.4        |
-----------------------------------------------------------------
```

3. Data base	IIIIIIIIIIIIIIIIIIIIII 1.6 IIIIIIIIIIIIIIIII	
administration	EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.1	
	CCCCCCCCCCCCCCCCCCCCCC 1.6 CCCCCCCCCCCCCCCCC	
4. Data entry	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 1.9	
procedures	EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.1	
	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 1.9	
	IIIIIIIIIIIIIIIIIIIIII 1.5 IIIIIIIIIIIIIIIIII	
A. Access	EEEEEEEEEEEEEEEEEEEEEE 1.7 EEEEEEEEEEEEEEEE	
	CCCCCCCCCCCCCCCCCCCCCC 1.5 CCCCCCCCCCCCCCCCCC	
B. Machine	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.2	
readable	EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.1	
documents	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.1	
C. Off-line	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.2	
manual	EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.3	
recording	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.2	
D. Scheduled on	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.0	
line manual	EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.3	
recording	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.0	
E. Event driven	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 1.8	
on-line man-	EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.3	
ual record.	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 1.8	
F. Automatic	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.0	
on-line	EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.3	
recording	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.0	
5. Processing	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.0	
modes--host	EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.3	
& time sharing	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.0	
A. Card	IIIIIIIIIIIIIIIIIIIIIIIII 3.5	
oriented	EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.3	
batch	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.3	
B. Keyboard	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.2	
oriented	EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.3	
batch	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.2	
C. Interactive	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.0	
computing	EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.1	
	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.0	
D. On-line	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.1	
inquiry	EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.1	
	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.1	

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-----------------------------------------------------------------------
    E. Data         |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 1.8     |
       acquisition  |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.1        |
       and control  |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 1.8     |
-----------------------------------------------------------------------|
6.  Data            |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.1        |
    transmission    |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.6             |
                    |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.1        |
-----------------------------------------------------------------------|
    A. Data         |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.1        |
       conversion   |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.8               |
                    |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.1        |
-----------------------------------------------------------------------|
                    |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.2         |
    B. Transmission |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 3.0                 |
                    |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.2         |
-----------------------------------------------------------------------|
                    |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 1.8     |
    C. Data control |EEEEEEEEEEEEEEEEEEEEEE 1.6 EEEEEEEEEEEEEEEEE       |
                    |CCCCCCCCCCCCCCCCCCCCCC 1.6 CCCCCCCCCCCCCCCCC       |
-----------------------------------------------------------------------|
7.  Processing      |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.1        |
    concepts        |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.6             |
                    |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.1        |
-----------------------------------------------------------------------|
    A. Program      |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.8  |            |
       loading      |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.9   |            |
                    |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.8  |            |
-----------------------------------------------------------------------|
                    |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.8  |            |
    B. File loading |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.9   |            |
                    |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.8  |            |
-----------------------------------------------------------------------|
    C. Instruction  |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.8  |            |
       execution    |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 3.0    |            |
                    |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.8  |            |
-----------------------------------------------------------------------|
    D. Program and  |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.1        |
       record       |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.6             |
       fixes        |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.1        |
-----------------------------------------------------------------------|
    E. Recovery/    |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 1.8     |
       restart      |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.7              |
                    |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 1.8     |
-----------------------------------------------------------------------
```

AREA V: Data Processing Management	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 1.8
	EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.1
	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 1.8
1. Personnel management	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.4
	EEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 3.0
	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.4
A. Staffing	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.9
	EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.8
	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.8
B. Evaluation	IIIIIIIIIIIIIIIIIIIIIIIIIIIIII 3.0
	EEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 3.0
	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 3.0
C. Scheduling	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.8
	EEEEEEEEEEEEEEEEEEEEEEEEEEEEE 3.1
	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.8
D. Training	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.6
	EEEEEEEEEEEEEEEEEEEEEEEEEEEE 3.2
	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.6
2. Organizational management	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 1.8
	EEEEEEEEEEEEEEEEEEEEEE 1.4 EEEEEEEEEEEEEEEEEEE
	CCCCCCCCCCCCCCCCCCCCCC 1.4 CCCCCCCCCCCCCCCCCCC
A. DP organizational structure	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 1.8
	EEEEEEEEEEEEEEEEEEEEEE 1.4 EEEEEEEEEEEEEEEEEEE
	CCCCCCCCCCCCCCCCCCCCCC 1.4 CCCCCCCCCCCCCCCCCCC
B. Relationships with other depts.	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 1.8
	EEEEEEEEEEEEEEEEEEEEEE 1.3 EEEEEEEEEEEEEEEEEEEE
	CCCCCCCCCCCCCCCCCCCCCC 1.3 CCCCCCCCCCCCCCCCCCCC
C. Separation of responsibility	IIIIIIIIIIIIIIIIIIIIII 1.6 IIIIIIIIIIIIIIIII
	EEEEEEEEEEEEEEEEEEEEEE 1.2 EEEEEEEEEEEEEEEEEEEEE
	CCCCCCCCCCCCCCCCCCCCCC 1.2 CCCCCCCCCCCCCCCCCCCCC
3. Facilities management	IIIIIIIIIIIIIIIIIIIIII 1.6 IIIIIIIIIIIIIIIII
	EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.2
	CCCCCCCCCCCCCCCCCCCCCC 1.6 CCCCCCCCCCCCCCCCC
A. Environment	IIIIIIIIIIIIIIIIIIIIII 1.7 IIIIIIIIIIIIIIII
	EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.2
	CCCCCCCCCCCCCCCCCCCCCC 1.7 CCCCCCCCCCCCCCCC
B. Access control	IIIIIIIIIIIIIIIIIIIIII 1.5 IIIIIIIIIIIIIIIIII
	EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.0
	CCCCCCCCCCCCCCCCCCCCCC 1.5 CCCCCCCCCCCCCCCCCC

Item	I	E	C
4. Data processing operations management	1.7	2.0	1.7
A. Systems development/control	1.5	1.7	1.5
B. Prog. dev. maintenance, and control	1.6	1.8	1.6
C. Job scheduling	2.1	2.4	2.1
D. Charge-back methods	2.8	4.4	2.8
E. Planning	2.1	3.2	2.1
F. Records mgt. retention & control	2.1	2.0	2.0
a. Forms	2.3	2.2	2.2
b. Reports	2.1	2.0	2.0
c. Source documents	2.1	2.0	2.0
5. General knowledge of trends	2.5	3.3	2.5
A. Software	2.5	3.2	2.5
B. Hardware	2.5	3.3	2.5

C. Systems development	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII	2.5
	EEEEEEEEEEEEEEEEEEEEEEEEEE	3.4
	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	2.5
D. Applications	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII	2.4
	EEEEEEEEEEEEEEEEEEEEEEEEEEE	3.3
	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	2.4
E. Programming techniques	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII	2.5
	EEEEEEEEEEEEEEEEEEEEEEEEEE	3.4
	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	2.5
6. Evaluation and contracting for	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII	2.8
	EEEEEEEEEEEEEEEEEEEEEEEE	3.6
	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	2.8
A. Software	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII	2.5
	EEEEEEEEEEEEEEEEEEEEEEEEEEE	3.3
	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	2.5
B. Hardware	IIIIIIIIIIIIIIIIIIIIIIIII	3.5
	EEEEEEEEEEEEEEEEEEEEEEEE	3.6
	CCCCCCCCCCCCCCCCCCCCCCCCC	3.5
C. Consultants	IIIIIIIIIIIIIIIIIIIIIIIIIIIIII	3.0
	EEEEEEEEEEEEEEEEEEEEEEEE	3.6
	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	3.0
7. Implications of	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII	2.4
	EEEEEEEEEEEEEEEEEEEEEEEEEEEEEE	3.0
	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	2.4
A. In-house vs. out-house software dev	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII	2.5
	EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE	2.8
	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	2.5
B. Purchase versus lease/rental	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII	2.6
	EEEEEEEEEEEEEEEEEEEEEEEE	3.6
	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	2.6
C. In-house vs. contract instal. mgt.	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII	2.4
	EEEEEEEE	5.2
	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	2.4
8. Current laws and regulations	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII	1.8
	EEEEEEEEEEEEEEEEEEEEEEEEEEEEEE	3.0
	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	1.8
A. Privacy	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII	1.8
	EEEEEEEEEEEEEEEEEEEEEEEEEEEE	3.2
	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	1.8

B. Reporting	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII	1.8
require-	EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE	2.6
ments	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	1.8
C. Trade se-	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII	2.1
crets, pats.	EEEEEEEEEEEEEEEEEEEEEEEEEEEE	3.3
& copyright	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	2.1

AREA VI: Audit	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII	1.8
Knowledge/	EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE	2.9
Techniques	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	1.8
1. Understand and	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII	2.0
be able to use	EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE	1.8
	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	1.8
	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII	2.2
A. Test decks	EEEEEEEEEEEEEEEEEEEEE	3.9
	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	2.2
B. Test data	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII	2.5
generators	EEEEEEEEEEEEEEEEEEEEEEEE	3.6
	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	2.5
C. Tagging a	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII	2.7
tracing	EEEEEEEEEEEEEEEEEEEEEEE	3.7
	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	2.7
D. Integrated	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII	2.6
test	EEEEEEEEEEEEEEEEEEEEEEEEEEEEE	3.2
facility	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	2.6
E. Live on-line	IIIIIIIIIIIIIIIIIIIIIIIIIIIIII	3.1
sampling	EEEEEEEEEEEEEEEEEEEEEEEEEEEEE	3.2
techniques	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	3.1
F. Logic	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIII	3.0
tracing	EEEEEEEEEEEEEEEEEEEEEEE	3.7
software	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	3.0
G. Code review	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII	2.7
and	EEEEEEEEEEE	4.9
comparison	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	2.7
a. Applica-	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII	2.6
tion	EEEEEEEEEEEEEEEE	4.4
programs	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	2.6

b. Utility	IIIIIIIIIIIIIII 4.5
programs	EEEEEEEEEEEEE 4.7
	CCCCCCCCCCCCCCC 4.5
c. Operating	IIIIIIIIIIIIIIIIII 4.2
system	EEEEEEEEEEEEEEEEEEE 4.1
programs	CCCCCCCCCCCCCCCCCCC 4.1
H. Flowcharting	IIIIIIIIIIIIIIIIIIIIIIIIII 3.4
software	EEEEEEEEEEEEEEEEEEE 4.1
packages	CCCCCCCCCCCCCCCCCCCCCCCCCC 3.4
I. Data retrie-	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.0
val using	EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.9
utility prog	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.0
J. DBMS data/	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 1.8
record	EEEEEEEEEEEEEEEEEEEEEEEEEE 3.4
retrieval	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 1.8
K. Parallel	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.4
simulation	EEEEEEEEEEEEEEEEEE 4.2
	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.4
L Generalized	IIIIIIIIIIIIIIIIIIIIII 1.6 IIIIIIIIIIIIIIIII
audit	EEEEEEEEEEEEEEEEEEEEEE 1.3 EEEEEEEEEEEEEEEEEEEE
software	CCCCCCCCCCCCCCCCCCCCCC 1.3 CCCCCCCCCCCCCCCCCCCC
M. Ability to	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.0
prog. custom	EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 2.9
audit softw.	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 2.0
2. Computer inter-	IIIIIIIIIIIIIIIIIIIIII 1.3 IIIIIIIIIIIIIIIIIIII
nal control/	EEEEEEEEEEEEEEEEEEEEEE 1.4 EEEEEEEEEEEEEEEEEEE
vulnerabilities	CCCCCCCCCCCCCCCCCCCCCC 1.3 CCCCCCCCCCCCCCCCCCCC
	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 2.0
A. Hardware	EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE 1.9
	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC 1.9
	IIIIIIIIIIIIIIIIIIIIII 1.4 IIIIIIIIIIIIIIIIIII
B. Software	EEEEEEEEEEEEEEEEEEEEEE 1.3 EEEEEEEEEEEEEEEEEEEE
	CCCCCCCCCCCCCCCCCCCCCC 1.3 CCCCCCCCCCCCCCCCCCCC
C. Organiza-	IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII 1.8
tional	EEEEEEEEEEEEEEEEEEEEEE 1.2 EEEEEEEEEEEEEEEEEEEEE
	CCCCCCCCCCCCCCCCCCCCCC 1.2 CCCCCCCCCCCCCCCCCCCCC
D. Data	IIIIIIIIIIIIIIIIIIIIII 1.4 IIIIIIIIIIIIIIIIIII
processing	EEEEEEEEEEEEEEEEEEEEEE 1.3 EEEEEEEEEEEEEEEEEEEE
procedures	CCCCCCCCCCCCCCCCCCCCCC 1.3 CCCCCCCCCCCCCCCCCCCC

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  E. User           |IIIIIIIIIIIIIIIIIIIIII 1.2 IIIIIIIIIIIIIIIIIIIII |
     procedures     |EEEEEEEEEEEEEEEEEEEEEE 1.2 EEEEEEEEEEEEEEEEEEEEE |
                    |CCCCCCCCCCCCCCCCCCCCCC 1.2 CCCCCCCCCCCCCCCCCCCCC |
-----------------------------------------------------------------------|
  F. Sys. design,   |IIIIIIIIIIIIIIIIIIIIII 1.4 IIIIIIIIIIIIIIIIIII   |
     devop. and     |EEEEEEEEEEEEEEEEEEEEEE 1.4 EEEEEEEEEEEEEEEEEEE   |
     implementat.   |CCCCCCCCCCCCCCCCCCCCCC 1.4 CCCCCCCCCCCCCCCCCCC   |
-----------------------------------------------------------------------|
  G. Documenta-     |IIIIIIIIIIIIIIIIIIIIII 1.3 IIIIIIIIIIIIIIIIIIII  |
     tion           |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE  1.8 |
                    |CCCCCCCCCCCCCCCCCCCCCC 1.3 CCCCCCCCCCCCCCCCCCCC  |
-----------------------------------------------------------------------|
                    |IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII  2.1     |
  H. Forms          |EEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEEE  2.0    |
                    |CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC  2.0    |
-----------------------------------------------------------------------|
                    |IIIIIIIIIIIIIIIIIIIIII 1.5 IIIIIIIIIIIIIIIIII    |
  I. Data entry     |EEEEEEEEEEEEEEEEEEEEEE 1.7 EEEEEEEEEEEEEEEE      |
                    |CCCCCCCCCCCCCCCCCCCCCC 1.5 CCCCCCCCCCCCCCCCCC    |
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Analysis of the Survey Results

Analysis of the Significant Differences Between the Internal and External Audit Responses

The analysis of the differences between the internal and external auditors was completed on the basis of the Phase III survey results and the assessment of the researcher. The major analysis consisted of a Man-Whitney/Wilcoxon test of paired data to identify differences at the question level. This was followed by an examination of the knowledge requirements for which the two populations were significantly different.

Initially a multivariate analysis of variance (MANOVA) was used, employing the six overall area questions to determine if there was a significant difference between the internal and external auditor data processing requirements. A one-tailed test was used since it was hypothesized that the internal auditors would need a higher level of data processing knowledge than the external auditors due to their broader audit responsibility. The MANOVA results supported the hypothesis at the ninety-three percent level of significance. This result is supported by the fact that both groups reached consensus on each of the six questions and the internal audit level of importance was higher for each question.

The Man-Whitney/Wilcoxon test was used to identify the specific questions for which the level of importance assigned by internal and external auditors was significantly different, as well as the magnitude of the difference. The analysis results indicate that there are significant differences in the responses of 146 of the 295 survey questions. This represents fifty-one percent of the questionnaire. The level of importance assigned by external auditors was higher than the level of importance assigned by the internal audit for six of the 146 questions or four percent of the 146 questions. The test results are consistent with the differences in audit responsibilities between internal and external auditors and also consistent with the MANOVA results.

The questions on which the audit groups differ do form a consistent and coherent pattern. The questions are listed along with the corresponding alpha level and the direction of the difference--(I>E) when the internal audit level of importance is higher than the external audit level of importance. Conversely, the direction of the difference is shown as (E>I) when the external audit level of importance is higher.

Question Nr./Knowledge Description	Difference	Alpha
AREA I: COMPUTER HARDWARE		
1. A. Major types of computers--analog	I>E	.02
C. Oper. sys.--multiprogramming	I>E	.002
D. Oper. sys.--Multiprocessing	I>E	.003
E. Oper. sys.--Virtual	I>E	.001
5. Storage mediums	I>E	.04
A. Primary memory -- core,	I>E	.03
6. I/O and storage devices	I>E	.05
H. Microfilm	I>E	.03
K. Point-of-sale	I>E	.04
7. Communications	I>E	.001
A. Modems/data sets	I>E	.02
B. Line controllers	I>E	.002
C. Multiplexers/selector channels	I>E	.003
D. Concentrators	I>E	.01
E. Types of channels	I>E	.003
G. Cryptographic devices	I>E	.01
A. Keypunch	I>E	.05
B. Verifier	I>E	.05
10. Hardware related techniques	I>E	.01
A. Parity	I>E	.02
B. Buffering	I>E	.04
C. Modularity	I>E	.02
D. Protocols	I>E	.05

E. Acknowledgement	I>E	.01
F. Packet switching	I>E	.02
11. Specialized systems	I>E	.02
A. Data entry	I>E	.01
B. Word processing	I>E	.001
12. Operation of components as a system	I>E	.02
A. Data transmission	I>E	.001
B. Data control	I>E	.02
C. Data manipulation	I>E	.01

AREA II: Software		
1. Available languages	I>E	.03
B. Data base management system	I>E	.05
C. Specialized inquiry/report	I>E	.01
E. Modeling/simulation	I>E	.04
2. Language classifications	I>E	.01
B. Procedural/non-procedural	I>E	.02
3. B. Types of programs--utility	E>I	.01
D. Translator	I>E	.02
4. D. Electronic funds transfer system	E>I	.02
E. Electronic mail systems	I>E	.001
5. Understand programming techniques	I>E	.001
6. Operation of the major types of DBMS	I>E	.01
A. Modification of operating system	I>E	.01
B. Interfaces with existing OS	I>E	.02

C. Used with back-end processor	I>E	.01
7. The structure of software	I>E	.001
A. System architecture	I>E	.002
B. Instruction formats	I>E	.002
C. Program construction	I>E	.002
E. Operating system structure	I>E	.002
9. Software trends	I>E	.01

AREA III: Systems Analysis and Design	I>E	.01
1. Systems development methodologies	I>E	.004
2. Systems study procedures	I>E	.02
C. Feasibility study	I>E	.01
D. Systems study	I>E	.01
F. Systems testing	I>E	.01
H. Conversion techniques	I>E	.10
I. Systems/program maintenance	I>E	.02
3. Ability to design a simple system	I>E	.01
A. Batch	I>E	.02
B. On-line -- few interfaces	I>E	.02
5. Able to program	I>E	.001
A. Program assembly language	I>E	.02
B. High level language	I>E	.002
C. DBMS language	I>E	.02
E. At least one language	I>E	.01
6. B. Design/use--multiple organ. sys.	I>E	.03

	C. Spec. files--indices, tables, etc	I>E	.003
	D. Coding systems	I>E	.02
	E. Multimode processing systems	I>E	.004
	F. Recovery/restart procedures	I>E	.001
	G. Operating systems	I>E	.0003
7.	D. Integrated data base--batch proc.	I>E	.04
	E. Integrated data base--real time	I>E	.03
	F. Shared files	I>E	.01
	G. Special reports files	I>E	.01
	H. Operating system records/files	I>E	.002
9.	Diagnostic aids	I>E	.01
	B. Hardware monitors	I>E	.04
10.	B. Applications--decis. sup. models	I>E	.003
	b. Production--data acquistion	I>E	.05
	c. Electronic mail	I>E	.01
11.	Types of documentation	I>E	.002
	A. Program	I>E	.002
	B. System	I>E	.003
	C. Data processing operations	I>E	.004
	D. User	I>E	.02
12.	D. Charts--statistical	I>E	.04
13.	Specific types of charting	I>E	.05
	A. Program logic	I>E	.004
	C. Systems flowchart	I>E	.01
	D. Process flowcharts	I>E	.004

E. Gantt	I>E	.03
14. Solution alternatives	I>E	.04
C. Softw. dev.--in-house, contract..	I>E	.01
E. Time sharing, purchase, lease .	I>E	.04
15. C. c. Processing control--oper. sys	I>E	.02
d. (1). Time sharing - 3rd party	I>E	.02
(2). DBMSs	I>E	.03
(3). Communication networks	I>E	.01
E. Documentation	I>E	.003

AREA IV: DP Operations (DP & users)		
3. Data base administration	I>E	.04
E. Event driven on-line man. record.	I>E	.05
6. Data transmission	I>E	.05
A. Data conversion	I>E	.05
B. Transmission	I>E	.02
7. E. Recovery/restart	I>E	.01

AREA V: Data Processing Management		
1. D. Personnel management	I>E	.05
C. Training	I>E	.03
2. B. Relationships with other departm.	E>I	.04
3. Facilities management	I>E	.04
A. Environment	I>E	.05
4. E. Planning	I>E	.01

5. General knowledge of trends	I>E	.01
A. Software	I>E	.01
B. Hardware	I>E	.01
C. Systems development	I>E	.002
D. Applications	I>E	.004
E. Programming techniques	I>E	.004
6. Evaluation and contracting for	I>E	.01
A. Software	I>E	.01
B. Hardware	I>E	.02
C. Consultants	I>E	.04
7. Implications of	I>E	.02
B. Purchase versus lease/rental	I>E	.01
C. In-house vs contract instal. mgt.	I>E	.003
8. Current laws and regulations	I>E	.002
A. Privacy	I>E	.001
B. Reporting requirements	I>E	.02
C. Trade secrets, pat., & copyright	I>E	.002

AREA VI: Specialized Audit Knowledge and Techniques		
1. Understand and be able to use	E>I	.01
B. Test data generators	I>E	.002
C. Tagging and tracing	I>E	.005
D. Integrated test facility	I>E	.04
F. Logic tracing software packages	I>E	.02

G. Code review and comparison	I>E	.02
a. Application programs	I>E	.05
c. Operating system programs	I>E	.05
H. Flowcharting software packages	I>E	.02
J. DBMS data/record retrieval	I>E	.02
K. Parallel simulation	I>E	.01
M. Program custom audit software	I>E	.01
2. C. Internal control/vulner. organiz.	E>I	.03

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The analysis of the significant differences between the survey questions revealed a coherent pattern in two aspects. First, the evaluations for a given knowledge area were consistent, except for knowledge items that represented obsolete technology or techniques. Second, the evaluation differences were generally consistent with the nature and practice of internal and external audit. The external auditor's objective is to make an examination of the computer installation and data processing activities in accordance with generally accepted auditing standards in order to form an opinion as to whether the financial statements fairly reflect the financial position, results of operations, and changes in financial position in conformity with consistently applied generally accepted accounting principles. In contrast, the internal auditor's objective is to examine and evaluate the firm's organizational components in terms of the quality of their performance and the efficiency and effectiveness with which they use assigned resources to fulfill their responsibilities. In addition, internal auditors must recommend improvements and changes in operations when needed to bring the firm's operations into acceptable procedures and practices consistent with the firm's policies and objectives. The internal auditor's examination of data processing activities is from two perspectives. The first perspective concerns the ramifications of data processing as a facilitating activity for all entities of the firm. The second perspective is an evaluation of data processing as an organizational entity.

The differences in audit responsibility and modus operandi account for many of the significant differences identified in the analysis. In the hardware and related software areas, internal auditors evaluated several areas as more important due to their application and importance in the daily operation of businesses. Analog systems were assessed as moderately important by internal auditors (mean = 3.7) and unimportant by external auditors (mean = 4.4). Analog computers have been used by the process industries for several years and analog to digital converters have become more economical in recent years. The resulting increase in the number of these analog-based devices, which are often integrated into digital systems, has increased their importance to internal auditors. These analog applications have little impact upon external auditors since the data generated has no material impact upon the financial statements of the firm.

The survey results indicate the need for internal auditors to have a more thorough understanding than external auditors of the more sophisticated computer operating systems. These systems perform many management and control functions that are important to the daily operation of the firm as well as being important to the management of the data processing installation. The effectiveness of the more sophisticated audit transaction sampling techniques is dependent upon the modification of the operating system. The consensus of the external audit experts was that a general knowledge of these systems was sufficient. The thrust of two of the external auditor-shared comments was that the operating system should be left up to specialists because of its complexity. The determination of the researcher was that the area should be of equal importance to both audit groups due to the potential for accidental and designed distortion of financial and other operating data. The operating system is an area of increasing concern because more businesses are modifying their computer operating systems in order to improve their processing facility.

The modification process can inadvertently disarm control features that were designed into the system. In addition, remodifications often have to be made when subsequent vendor program enhancements and fixes are received. The latter further increases the chances of error and fraud.

There were several significant differences between questions relating to data preparation, entry, communication, and storage. The internal audit experts generally rated these areas one level above the external audit experts. Data entry is a human resource intensive area that must be given continual attention to assure that the firm's operational and financial data is accurate. Technological advances have been less dramatic in this area than in the processor and storage areas. The results of the computer fraud analyses indicated that data entry is the area that requires the lowest level of data processing knowledge to perpetrate computer fraud. The accuracy and safety of the firm's operational and financial data is dependent upon effective hardware, software, and management controls. The researcher's preconception of the data entry area was that it was of equal importance to internal and external auditors due to the potential for introducing inadvertent and false information into the management information system.

Data communications is an area of growing importance. The survey results indicate that internal auditors need a general knowledge of the area while external auditors need only be familiar with the area. These results were expected since distributed systems and other electronically connected applications are not yet widespread. These systems are logically complex and difficult to implement. They are more important to internal auditors since many businesses are in various stages of implementing this relatively new system technology. The area should become more important to external auditors as more operational and financial data flows over communication networks. During the survey phase a few internal and external experts indicated that the area was very important for auditors involved with financial institutions where electronic funds transfer systems were in use.

There were significant differences in the majority of questions in the software and systems analysis and design areas. These differences are particularly easy to understand since the participation of internal auditors in these activities result in long-term benefits for the firm. Controls can be initially designed into a system much more effectively and economically than they can be retrofitted at a later date. The external audit experts recognized the importance of understanding this process as is evidenced by their evaluations which were generally a level lower than the internal auditors. The external auditors evaluations of the importance of programming was lower than the researcher anticipated and also less important than indicated by the Roy and McNeill, and the Jancura studies. The other evaluations of both groups closely reflected the assessment of the researcher.

With one major exception, the significant differences in the data processing operations, data processing management, and the specialized audit knowledge areas followed the general pattern of the other three areas. The level of importance assigned to organizational relationships by the internal audit group was consistently lower than that assigned by the external audit group. Much of the control achieved organizationally in a manual system is lost in computer systems due to the functions assumed by the computer and the data processing staff.

This loss of separation should increase the audit importance of the relationships of data processing with other organizational elements as well as other organizational relationships within the firm. The increased use of data base management systems and distributed processing should further increase the importance in the future, since these systems provide the capability for users to add, delete, and modify operational files and data. The researcher felt that these areas should be as important to internal auditors as they are to external auditors.

The Analysis of Areas Where Consensus Was Not Reached

There were two knowledge items for which the expected consensus was not achieved. The external auditors did not reach consensus on the required knowledge level for digital computers, but did reach consensus with a slightly higher mean for the required knowledge of major types of computers. The digital knowledge item received judgments of four and five which indicated respectively that auditors should be generally familiar with the area or that the knowledge was desirable but not required. This is surprising in that all of the studies identified in the research phase of the study supported a higher level of knowledge for this area. Shared rationale asserted that audit trails and controls are generally independent of types of hardware and dependent upon software. The researcher's judgment was that an understanding of software requires an understanding of the operation of the hardware.

The other knowledge item where consensus was expected, but did not occur, was the requirement that internal auditors have a sufficient knowledge of utility programs to be able to use them in their audit work. These programs provide capabilities that are very useful to auditors including data searchers, manipulation, retrieval, computation, reports and other uses. No rationale was provided for the low judgment.

CHAPTER V

A REVIEW OF THE DATA PROCESSING CONTENT OF FIVE-YEAR ACCOUNTING PROGRAMS

In Chapter IV internal, external, and composite profiles were developed from the survey results. The composite profile provides a conservative representation of the data processing knowledge requirements of internal and external auditors based on the reasoned judgments of internal and external auditors who are expert in the areas of data processing and auditing. The important data processing knowledge requirements should be reflected in the curricula of the schools of accountancy. The American Accounting Association and AICPA joint task force reviewed four-year accounting programs in 1974 and concluded that there was minimal emphasis on EDP in undergraduate auditing curricula. The recent emphasis has been on the need for five year programs for auditors due to the inability of the four year programs to prepare students adequately for entry into the profession.

At this time there are seventeen colleges which have five year programs that are accredited by the American Assembly of Collegiate Schools of Business (AACSB). Since these seventeen programs are in the early stages of development and other schools are in the process of being established, a review of how well these programs meet the data processing knowledge requirements of auditors is timely.

Letters were sent to each of the seventeen schools requesting information concerning the academic requirements of their program, a course outline, the textbook used for courses having data processing content, and planned changes. Seven schools provided information about their programs. Five of the schools provided the full complement of materials; one provided its published catalog and special program information; and one provided a listing of courses offered, and an outline of required and elective courses, and a brief description of the required introductory data processing course. Eighteen current, introductory data processing textbooks and eight auditing textbooks were reviewed to provide a better understanding of the breadth and depth of data processing course content. The CPA examination was mentioned frequently in the information provided by the schools. Therefore, to get a better understanding of the curricula, the CPA examinations for four recent years were reviewed, along with Irvin N. Gleim's solutions. The analysis of the curricula was based on the composite, data processing knowledge questions for which the level of importance was established as a value of one to three on the survey scale. A determination of the adequacy of the programs for data processing knowledge was made, comparing the materials received from the seven schools to the applicable survey area. The analysis is thus limited to comparisons and conclusions which can be made on the basis of the forty-one percent of the schools responding, and the variety of materials received.

The overall conclusion was that the required courses of the five year accounting programs do not meet the data processing knowledge requirements of internal and external auditors. The programs are better suited to meeting the data processing requirements of external auditors since their levels of required knowledge are in general lower and are directed at the areas impacting financial data. Most of the five year programs provided the student the opportunity to emphasize data processing subjects in their elective courses. However, approximately half of the schools had a very restrictive selection of elective data processing courses. These were more oriented to external auditors, since they were usually financially, as opposed to operationally, oriented.

All but one school required an introductory computer course that included some programming experience. The courses were usually the equivalent of three semester hours and were structured to provide coverage of the hardware, software, and introductory programming subject areas. They did not cover data processing operations (Survey Area IV), data processing management (Survey Area V), and advanced concepts such as special files, recovery, and production data acquisition. They also provided little or no coverage of data base management, distributed processing, data entry, electronic funds transfer and other specialized systems. It should be pointed out that there would not be time in an introductory three semester hour course, to introduce the student adequately to these advanced subjects.

Four of the seven schools required a course in accounting systems. An additional school indicated that it planned to require the course sometime in the near future. All of the other schools had an equivalent course that could be taken on an elective basis. The course outlines and textbooks reviewed suggested that these courses heavily emphasized the separation of responsibility, document flows, accounting controls, and a sampling of applications such as production, personnel, marketing, and inventory. Brief coverage was given occasionally to subjects such as systems development, data base management, and distributed processing.

Six of the seven schools had programs that permitted students to emphasize data processing on an elective basis. One school had a wide selection of elective data processing courses, three schools had four to five data processing courses, and two schools had two to three data processing courses. Only two or three schools had sufficient data processing courses and program time to meet the composite profile data processing knowledge requirements.

The comparison of the composite data processing knowledge profile and the materials supplied by the seven schools would indicate that a core of four three-semester hour courses should be required to meet the minimum composite data processing knowledge requirements. The present introductory computer course is needed and should be continued. The course provides the basic introduction to computer hardware, software, and programming (Survey Area I, II). The introductory course should be followed by a course that instructs the student in advanced data processing concepts, such as data processing operations, and data processing management (Survey Areas IV and V). The introductory and advanced concepts course would lay the foundation for the third course, which should address the systems development process (Survey Area III). The fourth course should provide the student the specialized, computer related, audit knowledge and tools that are needed to function effectively in the business environment (Survey Area VI).

CHAPTER VI

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

Introduction

The rapid rate of technological advances has greatly increased the processing capability, data storage capacity, and complexity of computer systems. At the same time, continual reductions in the cost of processing data have substantially increased the number of systems in use to the point where relatively small businesses are dependent upon computers for daily operation. Communication and software advances accompanying these events have increased the vulnerability of the data and assets managed through the use of these complex systems. Major computer frauds over past years have highlighted this vulnerability. These developments have underlined the importance of having internal and external auditors with the data processing expertise necessary to audit these systems adequately in order to assist business management and to protect the public interest. In recent years several studies have identified the need for internal and external auditors to improve their knowledge of data processing. At this time no minimum data processing knowledge requirements have been established by the IIA or the AICPA. Thus, there was a need for a study to define the data processing knowledge requirements of internal and external auditors. Since the curricula for the five year accounting programs are in the early stages of development, a review of how well these curricula meet the data processing knowledge needs of auditors was timely.

Summary

The major purpose of this study was to define the data processing knowledge requirements of internal and external auditors. Four subsidiary research questions were used to guide the research. Answers to these questions were obtained by identifying eighteen internal and eighteen external auditors who were expert in the areas of auditing and data processing. These experts participated in a three-phased Delphi survey using an open-ended questionnaire containing 295 questions. They used an evaluation scale with a range of one to six to assign a level of importance to each of the 295 questions. A value of one indicated the knowledge was essential and a value of six indicated the knowledge was not relevant. The internal and external audit experts used the evaluation scale in conjunction with the current technology computer installation characteristics and appropriate audit scope (IIA or AICPA) as a basis for their judgments. The installation characteristics provided a known basis for the knowledge determinations and the specification of the audit scope standardized the audit responsibility of the expert judgments. The latter was particularly important for the internal audit group, since audit responsibilities vary from firm to firm. Fifteen of the internal and fourteen of the external auditors completed all three survey phases. No questions were added by the study participants. The Phase III survey results were used to construct internal, external, and composite auditor data processing knowledge profiles. The guidelines for constructing the profiles were designed to provide a conservative statement of data processing knowledge requirements. In cases where the group reached consensus, the group mean was used as the importance level. Consensus was defined as applying only to those questions on which all respondents evaluated the importance within a range of two. In cases where consensus was not reached, the group mean less the standard deviation was used as the importance level. The composite profile was constructed using the highest importance assigned to each question. The composite profile was used as the basis for evaluating the coverage provided by seven of seventeen AACSB accredited five year accounting programs. The four subsidiary research questions are used as a guide for summarizing the study results.

1. What data processing knowledge is required by internal auditors to audit current technology computer systems?

The internal audit experts reached consensus on 242 or 82% of the 295 questions. Their judgments defined a data processing knowledge requirements profile that was consistent with the IIA audit responsibility and the technology found in computer-based management information systems. The system analysis area was the most important area, with individual ratings ranging from very important to important. The data processing operations, data processing management, audit techniques, and software areas were all rated as important. The lowest importance was assigned to hardware. The individual ratings ranged from moderately important to important.

2. What data processing knowledge is required by external auditors to audit current technology computer systems?

The external audit experts reached consensus on 253 or 86% of the 295 questions. Their judgments also defined a data processing knowledge requirements profile that was consistent with their audit responsibility and the technology relevant to the processing of financial data in computer based management information systems. The data processing operations, data processing management, software, and the systems analysis areas were all rated as important. The computer hardware and audit techniques areas were rated as moderately important.

3. What are the differences in the data processing knowledge required by internal and external auditors?

Analysis of the internal and external profiles revealed that the data processing knowledge requirements of internal auditors are generally higher than the data processing knowledge requirements for external auditors. According to the MANOVA, the survey results for the two groups were statistically different at the 93% level of significance. This means that under the hypothesis that there are no differences between the data processing knowledge requirements of internal and external auditors, the probability of getting the Phase III survey differences or even greater differences is 7%. The MANOVA was based on the six major knowledge area questions. The internal audit group rated each knowledge area as being more important than did the external audit group. According to the Man-Whitney/Wilcoxon test of paired data, the survey results were statistically different for 146, or 51% of the 295 questions at the 95% level of significance. Again, under the hypothesis that there are no differences between the data processing knowledge requirements of internal and external auditors, the probability of getting these differences or even greater differences is 5%. The knowledge level for the internal audit experts was higher than the knowledge level for the external audit experts for 140, or 96% of the 146 questions. The system analysis and audit techniques were the major areas of differences between the two audit groups. The internal auditors evaluated the areas respectively as very important to important and important. The external audit experts evaluated the areas respectively as important and moderately important.

4. Do the curricula of the selected five year accounting programs recognize the data processing knowledge required by internal and external auditors?

The analysis of the seven accounting programs indicated that the required courses do not meet the data processing knowledge requirements contained in the composite profile. Most of the programs provided students the opportunity to emphasize data processing in their selection of elective courses. One school provided a wide range of elective courses, three schools provided four to five courses, and two schools provided two or three courses. Only three of the schools had the combination of elective courses and sufficient elective hours that would meet the data processing knowledge profile requirements.

Conclusions

The study results determined that there is sufficient agreement among internal and external audit experts to establish the data processing knowledge requirements of internal and external auditors. The results also indicate that the internal auditor data processing knowledge requirements are higher generally than the requirements for external auditors. The study found that the required courses of the five-year accounting programs do not meet the data processing needs of the audit professionals. The conclusions suggest some actions that should be formally stated:

1. The IIA and AICPA should formally establish minimum data processing knowledge objectives for their respective professions. A formal statement would indicate a recognition of the importance of data processing and provide useful information to schools for educational programs, to firms for the professional development of their auditors, and to auditors and students for guiding individual study.

2. The IIA and AICPA should work with the schools of accountancy to improve the data processing course offerings and align the course requirements with the needs of the profession. This action is particularly important for the IIA, since current course requirements appear to be more financially oriented.

3. The IIA, AICPA, EDP Audit Foundation, and other organizations involved in the certification of auditors should review their certification programs and assure that they require a realistic level of data processing knowledge to pass. Accounting schools, students, and employers value the existing certification programs and rely on them as an indication that the individual who passes them has at least a minimum level of the required professional knowledge.

4. Schools of accountancy should critically review their programs to see if they prepare their internal and external audit graduates to cope effectively in the computer-oriented business environment.

5. Businesses should make a careful assessment of the data processing qualifications required for their internal audit openings and make the qualifications known to the accounting schools.

Recommendations for Future Research

The study results suggest two major areas that need further research. The first is a study of accounting school curricula with respect to the balance of required courses between accounting, auditing, data processing, and general business. The curricula reviewed were intensive in the accounting area but generally were inadequate in the data processing area. Some of the required accounting courses appeared to have less utility than the data processing knowledge requirements identified in this study.

The second area in which research is needed concerns the data processing knowledge requirements of government auditors. During the curricula review it was noted that two schools had separate programs for government auditors. The data processing requirements for these two programs were the same as those for the business internal audit programs. A Delphi study should be conducted of government internal auditors to see if the data processing knowledge requirements are the same as for the business internal audit programs. The study should be conducted using separate surveys for the Federal, state, and local levels.

APPENDIX A

NOTED ACADEMICIANS WHO REVIEWED THE SURVEY INSTRUMENT

Dr. Martin L. Bariff, Professor, Department of Management Studies, Case Western Reserve University. Also Director for Research and Chairman of the Body of Knowledge Project for the EDP Auditors Foundation. Dr. Bariff has presented several papers on the research subject and is in demand as a speaker.

Professor Mary Lou C. Gammo, Department of Accounting, East Tennessee State. Also was a member of the recent AICPA study group on auditor knowledge areas.

Dr. Elise G. Jancura, Chairperson, Department of Accounting and Business Law, Cleveland State University. Also chairs the AICPA Computer Education Committee, is a member of the AICPA Computer Curriculum Development Committee, and chaired the recent AICPA study of auditor knowledge areas. Author of book Audit and Control of Computer Systems and co-editor of the book Computers; Auditing and Control. She has authored numerous articles on the research subject (see the bibliography for a partial list).

Dr. Joseph J. Sardinas, Professor, Department of Accounting, University of Massachusetts. Also Coordinator of the University's annual Information Systems Program and editor of the proceedings. Co-author of book Computer Control and Audit: A Total Systems Approach and author of the book Computing Today.

APPENDIX B

COMPUTER FRAUD ANALYSIS

APPENDIX B

COMPUTER FRAUD ANALYSIS

The computer fraud cases were analyzed for the purpose of insuring that the study questionnaire contained the data processing knowledge areas required to understand computer fraud. Cases were selected to represent each of the following computer manipulation methods.

1. Transactions added, deleted, or altered

2. Files changed--records added, deleted, or altered

3. Program changes--instructions added, deleted, or altered

4. Improper operation to add, delete, modify, or copy data, programs, or program steps.

The cases are presented chronologically based on the dates the frauds were exposed. The reader may be familiar with some of the cases with different names, since some of them appeared in the literature under as many as three different names.

CASE 1: The ABC Produce Company--1962-69 (1)

Case Description

The chief accountant and administrative officer had worked for the ABC Produce Company and was enticed to come back to straighten out their records with a promise of a percentage of the profits. He convinced the company management that the use of a computer was necessary to handle the volume of transactions in a timely and accurate manner. The company started using a time-sharing service that the accountant had begun and operated. Neither the management nor the company auditor knew that the time-sharing service was owned by the accountant. At the end of the year, the accountant received a smaller bonus than was promised. He then developed an algorithm that allowed him to simulate and alter the accounts in varying patterns. The algorithm was used in conjunction with dummy accounts to steal over one million dollars over the next six years. The accountant decided that he had enough money and concluded there was no longer any need to work in an environment where he was not treated fairly. He could not quit his job because whoever took over the accounting would easily discover his fraud. He therefore purposely drew attention to the scheme by overdrawing the checking account of one of his dummy companies, with the expectation that he would draw only an eighteen month sentence. He received a ten year sentence due to his lack of remorse and refusal to return the money--serving five and one-half years before being paroled.

Suggested Auditor Data Processing Knowledge Areas:

1. Hardware--a working knowledge of digital computers
   A. I/O and storage devices
   B. PCAM equipment
2. Software--a working knowledge of application programs
   A. Types of programs
   B. Structure of programs
3. Systems analysis and design--working knowledge
   A. Ability to design a simple system
   B. The programming process
   C. Ability to program batch applications
   D. File organizations
   E. Documentation--system, program, and user
4. Data processing operations--general knowledge
   A. Card oriented batch

B. Processing concepts--working knowledge

(1) Program and file loading

(2) Recovery/Restart

CASE 2: Metropolitan Life and Honeywell--1971 (2)

Case Description

Three key Honeywell employees were on loan to Metropolitan Life for the purpose of running a weather forecasting service for Metropolitan Life's subscribers. The three were members of a data processing union that was having a dispute with Honeywell. Their objective was to discredit Honeywell by causing failure of the expensive Honeywell 1800. They were responsible for the operation of the system which collected weather data from 900 stations, computed weather statistics, and then provided weather information to subscribers. The system was designed so that the computer would direct the stations to rewind the paper tape drives. A second call collected the weather information that had been recorded on tape. The process was then repeated for control purposes and the data from the two readings compared for accuracy. The three Honeywell employees eliminated the flow of data by deleting the first rewind command from calls to twenty-two of the stations for which they knew the telephone numbers. This resulted in the data from the first call being matched against no data from the second call. The cause of the resulting system failure was not determined until an employee noticed an irregular program entry on the system log. The three men were caught while in the union hall deleting additional tape rewind commands.

<u>Suggested Auditor Data Processing Knowledge Areas</u>:

1. Hardware--working knowledge
   A. Operating system--working knowledge
   B. I/O and storage devices--working knowledge
   C. Communications--working knowledge
   D. Hardware related techniques--protocols and acknowledgement
   E. Security and control features
2. Software--working knowledge
   A. Types of programs--working knowledge
   B. Structure of software
3. Systems analysis and design
   A. Ability to program
   B. Control techniques--working knowledge

4. Data processing operations--working knowledge
   A. Data entry procedures--working knowledge
   B. Data acquisition and control--working knowledge

CASE 3: University Computing Company--1971 (3)

Case Description

Hugh Ward was employed by University, which, along with Information System Design Corporation, provided computer services to Shell Development Corporation. The two service bureaus provided a common identification number to Shell for operating convenience. Ward was able to learn the unlisted number for Information's dial-up port and also the program access numbers, which were published in a customer newsletter. He gained access to Information's computer and instructed it to punch out a proprietary engineering program at his location. Ward was not aware that Information's system did not have the access method to punch cards at a remote site. Unknown to Ward, the cards were punched out at the host site. He then directed that the program be printed at his location and this was accomplished. The next day the deck was delivered to Shell and an investigation eventually traced the call to University.

Suggested Auditor Data Processing Knowledge Areas:

1. Hardware--working knowledge
   - A. Operating systems--working knowledge
   - B. I/O and storage devices
   - C. Communications--general knowledge
   - D. Hardware related techniques--protocols and acknowledgement
   - E. Security and control features--general knowledge
2. Software--working knowledge
   - A. Types of programs--working knowledge
   - B. Structure of software--general knowledge
3. Systems analysis and design--general knowledge
   - A. Ability to program
   - B. File access techniques
   - C. Control techniques--general knowledge
4. Data processing operations--working knowledge
   - A. Data entry procedures
   - B. Processing modes--host and timesharing
   - C. Data transmission--working knowledge

CASE 4: Pacific Telephone and Telegraph--1971-72 (4)

Case Description

Jerry Schneider started picking up discarded manuals and equipment from the Pacific Telephone trash on the way to and from high school. By the time he began college, he had a complete set of Western Electric and Pacific manuals. These manuals provided system and user ordering procedures, account structures, budgetary limits, delivery procedures, and other operational information. He obtained the access and order entry codes through discussions with Pacific employees by posing as a writer or using some other false pretense. He purchased a key to a Pacific storage area from a friend, an old Pacific truck with the markings still intact, and a touch-tone data entry device used for order entry. For the next six to seven months he ordered equipment for delivery to authorized delivery sites and made the pickups using the truck. It is estimated that a million dollars worth of equipment was stolen prior to his activities being disclosed by an employee whom he had recruited to help because of the increasing volume. The employee became upset and quit when Schneider refused to give him a thirty dollar a week raise.

Suggested Auditor Data Processing Knowledge Areas:

1. Hardware--touch-tone data entry device
2. Order entry procedures

CASE 5: Equity Funding--1964-73 (5)

Case Description

The top management of Equity was functioning as a team to create the largest U.S. conglomerate by showing fast growth, increasing profitability, and the systematic acquisitions of highly profitable businesses. Their end objective appeared to be to acquire highly profitable companies through exchanges of stock, in order to phase out gradually the bogus policies. Instead, an increasing portion of their reported growth was generated through the creation and resale of additional bogus insurance policies and other illegal activities. The appearance of fast growth and increasing profitability was necessary to keep the price of Equity stock high enough to attract investors. The valued stock could then be used for acquiring highly profitable companies through an exchange of stock. Operating cash was generated from draining the acquired companies, reinsuring the bogus policies, as well as from legitimate operations. The number of fictional policies pyramided over the years until it reached 64,000 at the time the fraud was exposed by Ronald Secrist, a past employee who had been dismissed in an economy move. The computer was not the prime tool for the fraud but did play a critical enabling role. It was used to generate large volumes of needed documentation, to explain the overnight delays required to produce the documentation requested by auditors and examiners, and to explain management's inability to provide the complete information in the format desired by auditors and outsiders.

Suggested Auditor Data Processing Knowledge Areas:

1. Hardware--working knowledge
   - A. Printers and tape drives
   - B. Security and control features
2. Software--working knowledge
   - A. Utility programs
   - B. Operating system
3. Systems design--working knowledge
   - A. Batch file structure
   - B. Ability to program
   - C. Control techniques--able to understand and evaluate

(1) Job scheduling

(2) Records management--working knowledge

6. Specialized audit knowledge and techniques--understand computer internal control and vulnerabilities

   A. Hardware

   B. Software

   C. Organizational

   D. Data processing procedures

   E. User procedures

   F. Documentation

CASE 6: Union Dime Savings Bank--1970-73 (6)

Case Description

The Union Dime Savings Bank's chief teller felt he was overworked, and underpaid. He used the bank's error correction system to withdraw one and a half million dollars over a three year period. He used daily printouts to identify large deposits and dormant accounts. He then withdrew cash up to the FDIC insurance limit from those accounts to meet his cash needs. The shortages were then adjusted prior to the posting of quarterly interest. The cover-up was easy because the bank had two types of accounts that had posting dates that were three days apart, allowing him time to switch the shortages from one type of account to the other prior to the posting of interest. Any discrepancy reports generated by the depositor or auditor were referred to him for correction. This was done even if he was on vacation. He was careful to take short vacations. He was caught when the police raided a bookmaker and found records that indicated that he bet daily sums of up to 30,000 dollars on an annual salary of 11,000 dollars.

Suggested Auditor Data Processing Knowledge Areas:

1. Data entry procedures--user knowledge
2. Separation of responsibility
3. Security and control procedures

CASE 7: Security Pacific National Bank--1980 (7)

Case Description

Stanley Riffin was a self-employed computer consultant. He was given access to the wire room due to his consulting responsibilities with a bank contractor. The daily workload of the wire room involved approximately 1800 transactions amounting to four billion dollars.

After learning the operation of the system and the day's authorization code, Riffin called the bank using the current code and a fictitious name of a bank officer at a level high enough to order transfers, and directed that 10.2 million dollars be transferred to a New York bank. The funds were then transferred to Switzerland where Riffin purchased diamonds through an intermediary. He was caught when he tried to sell the diamonds to a friend who became suspicious and notified authorities.

Suggested Auditor Data Processing Knowledge Areas:

1. Systems design--security and control features
2. Data processing and communications operations--access control
3. Data processing and communications management
   A. Facilities Management--access control
   B. Evaluation and contracting for consultants
   C. Access control

CASE 8: TELENET--1980 (8)

Case Description

Four eighth grade students from Dalton High School wanted to see if they could get Pepsi delivered without being charged. They obtained the unlisted dial-up telephone number and used the password initially assigned to a cement company to gain entry into the Telenet system. Through trial and error they gained access to the master program that contained the passwords for other programs and then gained access to the files of twenty-one companies and universities. They reviewed numerous records, locked-out other users, and used time for programming. Telenet did not notice any irregularities until some of their subscribers started complaining about the difficulty they were having gaining access to the system. The four students' activities were detected by Telenet operators when they tied up a single entry telephone line, attempting to learn security access codes. The origin of the call was easily determined and the students caught. Unfortunately, they were not discovered until after one-fifth of the computer's secondary memory contents had been destroyed.

Suggested Auditor Data Processing Knowledge Areas:

1. Hardware
   A. Digital computers--working knowledge
   B. I/O and storage devices
   C. Hardware related techniques--protocols and acknowledgement

2. Software--general knowledge

   A. High level languages

   B. Structure of software

3. System design--general knowledge

   A. Able to program

   B. File structures--limited knowledge

4. Data processing operations--data entry procedures

5. Data processing management--access control

APPENDIX B: ENDNOTES

1. Parker, Crime by Computer, pp. 71-79, and Whiteside, Computer Careers, pp. 88-109.

2. Gerald McKnight, Computer Crime, pp. 121-129.

3. Parker, Crime by Computer, pp. 85-106 and Whiteside, Computer Careers, pp. 44-47.

4. Parker, pp. 59-70 and Whiteside, pp. 37-40.

5. Raymond L. Dirks and Leonard Gross, The Great Wall Street Scandal; Lee J. Seidler, Frederick Andrews, and Marc J. Epstein, The Equity Funding Papers; Parker, pp. 118-174; Whiteside, pp. 11-18; Emile Woolf, "Lesson of Equity Funding-the Ultimate Indictment," Accountancy, January 1977, pp. 30-40; Wyndham Robertson, "Those Daring Young Con Men of Equity Funding," Fortune, August 1973, pp. 81-132; and "On the Coast-to-coast Trail of Equity Funding," Finance, pp. 68-72.

6. Parker, pp. 192-203 and Whiteside, pp. 19-25.

7. Time, November 20, 1980, p. 48; The Wall Street Journal, November 6, 1980, p. 21 and November 7, 1980, p. 24.

8. Time, January 12, 1981, p. 6.

APPENDIX C

PARTICIPATING INTERNAL AUDIT EXPERTS AND COMPANIES

Mr. Charles E. Adams, Vice President and Auditor
BancOhio National Bank, Columbus, Ohio

Mr. John Paul Back, Senior Auditor--Computing
ARMCO, Incorporated, Middletown, Ohio

Mr. Robert K. Beiring, Senior Design Audit Specialist
The Procter & Gamble Company, Cincinnati, Ohio

Mr. James W. Hess, Jr., Manager International Auditing
The Goodyear Tire and Rubber Company, Akron, Ohio

Mr. Charles H. LeGrand, Manager
Information Systems Programs
The Institute of Internal Auditors, Incorporated
Altamonte Springs, Florida

Mr. James M. McClure, Manager, EDP Audit
The MEAD Corporation, Dayton, Ohio

Mr. George J. McGann, Assistant Audit Director
Allstate Insurance Company, Northbrook, Illinois

Mr. William E. Perry, President
William E. Perry Enterprises, Incorporated
Orlando, Florida

Mr. Kenneth Petrus, Manager, Information Systems Auditing
Kennecott Corporation, Niagara Falls, New York

Mr. Gary P. Sciko, EDP Audit Manager
The Sherwin Williams Company, Cleveland, Ohio

Mr. Robert Senften, EDP Auditor
AVCO Corporation, Newport Beach, California

Mr. Stephen E. Shelton, Data Systems Auditor
Sheller-Globe Corporation, Toledo, Ohio

Ms. Liey May Shue, District Manager--Internal Auditing
American Telephone & Telegraph Company
New York City, New York

Mr. Gary D. Smalley, Audit Manager--Systems & Service
The Standard Oil Company (Ohio), Cleveland, Ohio

Ford Motor Company, Dearborn, Michigan

APPENDIX D

PARTICIPATING EXTERNAL AUDIT EXPERTS AND COMPANIES

Mr. Russell E. Andrews, National Director of Computer Auditing, Laventhol & Horwath, Philadelphia, Pennsylvania

Mr. Eugene A. Blish, Audit Manager, National Office Fox & Company, Denver, Colorado

Mr. James A. Burgett, Partner George S. Olive & Company, Indianapolis, Indiana

Mr. Raymond W. Elliott, Director of National EDP, Coopers & Lybrand, New York, New York

Mr. Jim Gambill, EDP Audit Coordinator A. M. Pullen & Company, Greensboro, North Carolina

Mr. David C. Goodyear, Partner, National Director of Computer Audit, Main Hurdman and Cranstoun, New York, New York

Mr. Martin A. Grausam, EDP Audit Manager, Regional EDP Audit Specialist, Seidman & Seidman, Grand Rapids, Michigan

Mr. Donald M. Jacobs, National Director of Computer Services Pannell Kerr Forster, Denver, Colorado

Mr. Daniel A. Janko, National Manager of Computer Audit Alexander Grant & Company, Chicago, Illinois

Mr. Walter D. Pugh, Partner--Audit Research Price Waterhouse & Company, New York, New York

Mr. Robert S. Roussey, Partner, Director Auditing Procedures, Arthur Andersen & Company, Chicago, Illinois

Mr. Galen G. Vetter, Partner, EDP Audit Coordinator McGladrey Hendrickson & Company, Minneapolis, Minnesota

Mr. Kent Yarnall, National Director--Quantitative Audit Programs, Touche Ross & Company, New York, New York

APPENDIX E

PHASE I COVER LETTER, INSTRUCTIONS, AND

INTERNAL AND EXTERNAL AUDIT SCOPE

Date

Name/Address

Dear

Thank you for taking the time to participate in this important study. You were selected on the basis of your expertise in the fields of data processing (DP) and auditing. You, along with other selected experts, will assist in further defining the DP knowledge requirements for internal auditors charged with the responsibility for auditing computer-based management information systems.

The Delphi research methodology will be used to guide the survey process, since the definition of auditor DP knowledge requirements does not lend itself to precise analytical techniques. This methodology provides an effective system for structuring a group communication process that allows a group as a whole to deal with a complex problem. Specifically, the technique provides for the following:

1. Structured communication
2. Feedback of individual contributions of information and knowledge
3. Assessment of the group judgment
4. Anonymity for the responses of individuals

The following pages contain:

1. The survey procedure and organization of the survey instrument are provided as Attachment 1.
2. The survey instrument is Attachment 2.

You will be provided a summary of the survey results after they have been finalized and approved by the Research Committee at The George Washington University.

Your cooperation is essential and greatly appreciated. Please complete the questionnaire as quickly as possible and call me collect at (513) 529-7343 if you have any questions.

Sincerely yours,

Donald L. Dawley
Researcher

ATTACHMENT 1

THE SURVEY PROCEDURE

The survey procedure you will be following is organized into three phases.

Phase I: Initial evaluation of knowledge areas, major and minor knowledge items

1. Complete biographical information
2. Review the audit scope and model computer installation
3. Complete initial evaluation of the importance of the DP knowledge areas and items
4. Recommend additions/modifications to the questionnaire

Phase II: Evaluation of Revised Survey Instrument

1. Consider the group results from Phase I; that is the group range, median, and mean for each knowledge evaluation.
2. Re-evaluate based on the feedback of results and any reflective insights gained since Phase I.
3. Compare your evaluations to the group mean for each knowledge evaluation. If the difference is greater than 1, provide a brief rationale that can be shared anonymously with the group during Phase III.

Phase III: Final Evaluation

1. Consider shared anonymous rationale from Phase II
2. Finalize evaluation based on shared rationale and insights gained since Phase II

SURVEY INSTRUMENT ORGANIZATION

Section I: Biographical information. This will be used only to construct a profile of the participating experts.

Section II: Instructions for completing the survey instrument.

Section III: Summary of pertinent audit standards. These standards provide the audit scope that you are to use when evaluating the importance of the DP knowledge items.

Section IV: Current technology computer installation model. The model incorporates many of the latest hardware and software processing features in terms of processing power, complexity, and vulnerability. It also incorporates many of the high vulnerability internal data processing operations increasingly found at DP installations. The model is not intended to characterize a typical computer installation, but instead is to be used in conjunction with the audit standards in Section III to establish a common basis for determining the DP knowledge requirements of internal auditors.

Section V: Questionnaire. The questionnaire is open-ended to allow any additions or modifications necessary for an accurate determination of auditor DP knowledge requirements.

RESTRICTED

Your individual responses will be treated confidentially. Only the group results will be released and published.

SURVEY INSTRUMENT
FOR
DETERMINING THE DATA PROCESSING KNOWLEDGE AREAS FOR AUDITORS RESPONSIBLE FOR AUDITING CURRENT TECHNOLOGY COMPUTER SYSTEMS

Name ______________________________

Title ______________________________

Organization:

____

Office Phone: _____-______________

Address: ______________________________

____

Date ______________________________

Please refer any questions to:

Donald L. Dawley
Department of Production and
Decision Sciences
Miami University
Oxford, Ohio 45056
Telephone: (513) 529-7343
(Call Collect)

SECTION I: BIOGRAPHICAL INFORMATION

The responses to the following questions will be used only to describe the characteristics of the selected professionals as a group.

1. Years of audit experience.

   _____ Audit _____ EDP Audit _____ Audit Management

2. Years of data processing (DP) experience.

   _____ DP Operations _____ Programming

   _____ Systems development _____ DP Management

3. Number of related college courses taken. Mark the number of courses by category, such as 1, 2, 3. . . .

   _____ Introductory DP _____ Advanced DP

   _____ Programming _____ DBMSs

   _____ Distributed processing _____ Communications

   _____ System development _____ Audit

   _____ EDP Audit Other _____________

4. The number of related professional, technical, seminar, and conference courses taken.

   _____ Introductory DP _____ Advanced DP

   _____ Programming _____ DBMSs

   _____ Distributed processing _____ Communications

   _____ System Development _____ Audit

   _____ EDP Audit Other _____________

5. Professional attainment--check as appropriate.

   _____ CBA _____ CDP _____ CISA _____ CIA

   _____ CPA Other _____

6. Please indicate any college and graduate study.

Degree	Major	Minor

SECTION II: SURVEY INSTRUCTIONS

After completing the biographical information in Section I, review the audit scope and the computer installation model provided in Sections III and IV.

It is extremely important that the audit scope and computer installation model be used as the basis for your judgment of the importance of the DP knowledge areas and items identified in Section V. Past studies have addressed DP knowledge requirements without specifying the audit scope or system characteristics. The result has been the identification of DP knowledge requirements without a known or common basis. The currency and credibility of the results are therefore difficult to assess. This study is attempting to minimize the difficulty by establishing a common basis against which respondents can apply their knowledge and experience.

After you feel comfortable with the audit scope and model computer installation, evaluate each of the knowledge areas and items in Section V using the importance scale provided below. At the end of each knowledge area there is space for adding any knowledge items that you believe should be considered. Evaluate any added items and return the completed survey in the envelope provided.

Scale Reference	Definition
1. Very Important	This knowledge is essential. Must be thoroughly understood and applied. First order of priority.
2. Important	This knowledge is relevant. Must be sufficiently understood to apply. Second order of priority.
3. Moderately Important	This knowledge is usually relevant. A general knowledge is acceptable. Third order of priority.
4. Unimportant	Should be familiar with area. Seldom relevant. Last order of priority.
5. Most Unimportant	Knowledge desired but not required. Rarely relevant. No priority.
6. Not relevant	Should be dropped from consideration.

Provided as Appropriate

SECTION III: IIA AUDIT SCOPE

(Summary of Relevant Portions)

The internal auditing department is an integral part of the organization, and functions under the policies established by management and the board. The statement of purpose, authority, and responsibility (charter) for the internal auditing department, approved by management and accepted by the board, should be consistent with these Standards for the Professional Practice of Internal Auditing. The audit charter should be unrestricted. The internal auditor should:

Section

250 Possess the knowledge, skills, and disciplines essential to the performance of internal audits. .01.1 Proficiency in applying internal auditing standards, procedures, and techniques is required in performing internal audits. Proficiency means the ability to apply knowledge to situations likely to be encountered and to deal with them without extensive recourse to technical research and assistance.

280 Exercise due professional care in performing audits. .01 Due professional care calls for the application of the care and skill expected of a reasonably prudent and competent internal auditor in the same or similar circumstances. Professional care should be appropriate to the complexities of the audit being performed. In exercising due professional care, auditors should: (1) be alert to the possibility of intentional wrongdoing, errors, and omissions, inefficiency, waste, ineffectiveness, and conflicts of interest; (2) be alert to those conditions and activities where irregularities are most likely to occur; (3) identify inadequate controls and recommend improvements to promote compliance with acceptable procedures and practices.

300 Encompass the examination and evaluation of the adequacy and effectiveness of the organization's

system of internal control and the quality of performance in carrying out assigned responsibilities.

.02 The purpose of the review for adequacy of the system of internal control is to ascertain whether the system established provides reasonable assurance that the organizations' objectives and goals will be met efficiently and economically.

.03 The purpose of the review for effectiveness of the system of internal control is to ascertain whether the system is functioning as intended.

.05 The primary objectives of internal control are to ensure:

- .1 The reliability and integrity of information
- .2 Compliance with policies, plans, procedures, laws, and regulations
- .3 The safeguard of assets
- .4 The economical and efficient use of resources
- .5 The accomplishment of established objectives and goals for operations or programs

310 Review the reliability and the integrity of financial and operating information and the means used to identify, measure, classify, and report such information.

.01 Information systems provide data for decision making, control, and compliance with external requirements. Therefore, internal auditors should examine information systems and, as appropriate, ascertain whether:

- .1 Financial and operating records and reports contain accurate, reliable, timely, complete, and useful information.
- .2 Controls over record keeping and reporting are adequate and effective.

320 Review the systems established to ensure compliance with those policies, plans, procedures, laws, and regulations which could have a significant impact on operations and reports and should determine whether the organization is in compliance.

330 Review the means of safeguarding assets and, as appropriate, verify the existence of such assets. Auditors should review the means used to safeguard assets from various types of losses such as

theft, fire, improper or illegal activities, and exposure to the elements.

340 Appraise the economy and efficiency with which resources are employed.

350 Review operations or programs to ascertain whether results are consistent with established objectives and goals and whether the operations or programs are being carried out as planned.

400 Plan the audit, examining and evaluating information, communicating results, and following up.

420 Collect, analyze, interpret, and document information to support audit results.

.01.2 Information should be sufficient, competent, relevant, and useful to provide a sound basis for audit findings and recommendations.

Sufficient information is factual, adequate, and convincing so that a prudent, informed person would reach the same conclusions as the auditor.

Competent information is reliable and the best attainable through the use of appropriate audit techniques.

Relevant information supports audit findings and recommendations and is consistent with the objectives for the audit.

Useful information helps the organization meet its goals.

440 Follow up to ascertain that appropriate action is taken on reported audit findings.

Provided as Appropriate

SECTION III: AICPA PROFESSIONAL STANDARDS

(Summary of Relevant Portions)

This study concerns only the DP knowledge requirements with respect to the financial audits required by the securities laws and the SEC. It does not address the DP knowledge requirements necessary for management advisory services.

The independent auditor's objective is to make an examination of financial statements in accordance with generally accepted auditing standards in order to form an opinion as to whether or not the financial statements present fairly the financial position, results of operations, and changes in financial position in conformity with generally accepted accounting principles consistently applied.

The examination is influenced by the possibility of material errors or irregularities. The audit is conducted with an attitude of professional skepticism, recognizing that the application of auditing procedures may produce evidential matter indicating the possibility of errors or irregularities.

The examination must include a proper study and evaluation of the existing internal control as a basis for reliance thereon, and for the determination of the resultant extent of the tests to which auditing procedures are to be restricted. For computer based systems, the study includes two phases: (a) knowledge and understanding of the procedures and methods prescribed, and (b) a reasonable degree of assurance.

The auditor's concern for accounting control involves the organizational plan and the procedures and records that are concerned with the safeguarding of assets and the reliability of financial records and consequently are designed to provide reasonable assurance that:

a. Transactions are executed in accordance with management's general or specific authorization.
b. Transactions are recorded as necessary (1) to permit preparation of financial statements in

conformity with generally accepted accounting principles or any other criteria applicable to such statements, and (2) to maintain accountability for assets.

c. Access to assets is permitted only in accordance with management's authorization.

d. Recorded asset accountability is compared with the existing assets at reasonable intervals and appropriate action taken with respect to any differences.

The auditor must be able to collect evidential matter through the use of two general classes of auditing procedures:

a. Tests of details of transactions and balances, and

b. Analytical review procedures applied to financial information.

Since this study assumes complex EDP applications, the auditor is required to apply specialized expertise in EDP in the performance of the necessary audit procedures.

General controls comprise (a) the plan of organization and operation of the EDP activity, (b) the procedures for documenting, reviewing, testing and approving systems or programs and changes thereto, (c) controls built into the equipment by the manufacturer (commonly referred to as "hardware controls"), (d) controls over access to equipment and data files, and (e) other data and procedural controls affecting overall EDP operations.

Application controls relate to specific tasks performed by EDP. Their function is to provide reasonable assurance that the recording, processing, and reporting of data are properly performed. There is considerable choice in the particular procedures and records used to effect application controls. Application controls often are categorized as "input controls," "processing controls," and "output controls."

a. Input controls are designed to provide reasonable assurance that data received for processing by EDP have been properly authorized, converted into machine sensible form and identified, and the data (including data transmitted over communication lines) have not been lost, suppressed, added, duplicated, or otherwise improperly changed. Input controls include controls that relate to rejection, correction, and resubmission of data that were initially incorrect.

b. Processing controls are designed to provide reasonable assurance that EDP has been performed as intended for the particular application; that is, all transactions are processed as authorized, that no unauthorized transactions are omitted, and that no unauthorized transactions are added.

c. Output controls are designed to assure the accuracy of the processing result (such as account listings or displays, reports, magnetic files, invoices, or disbursement checks) and to assure that only authorized personnel receive the output.

The auditor must address the unique accounting control problems presented by EDP systems.

a. Incompatible functions--where DP and other personnel are in a position to perpetrate and conceal errors and irregularities in the normal course of their duties

b. Functions that would be considered incompatible if performed by a single individual in a manual activity are performed through the use of an EDP program or series of programs. A person having the opportunity to make unapproved changes to any such programs performs incompatible functions in relation to the EDP activity.

e. EDP data files frequently are basic records of an accounting system. They cannot be read or changed without the use of EDP, but they can be changed through the use of EDP without visible evidence that a change has occurred.

f. Supervisory programs are used in some EDP systems to perform generalized functions for more than one application program. Supervisory programs include (a) "operating systems," which control EDP equipment that may process one or more application programs at a given time, and (b) "data management systems," which perform standardized data handling functions for one or more application programs. An individual who can make unapproved changes in supervisory programs has opportunities to initiate unauthorized transactions that are like those of a person who can make unapproved changes in application programs or data files; he therefore performs incompatible functions.

SECTION IV: THE HYPOTHESIZED CURRENT TECHNOLOGY

Computer Installation Model

(Provided in Chapter III)

SECTION V: AUDITOR KNOWLEDGE QUESTIONNAIRE

(The questions are the same as Appendices H-M)

APPENDIX F

PHASE II SURVEY COVER LETTER, INSTRUCTIONS, AND SHARED RATIONALE FORM

Date

Name/Address

Dear

Thank you for the timely response to the Phase I survey. Since most of the Phase I surveys have been returned we will proceed with Phase II, without further delay. The knowledge items remain unchanged since no new items were submitted. The group statistics of some knowledge areas may change during Phase II, since everyone did not evaluate them during Phase I. Brief phrases have been added to clarify what is being evaluated.

The Phase II survey results depend upon an <u>independent</u> second evaluation. If you copied your Phase I responses, please <u>do not</u> refer to them until after you complete the Phase II procedure provided as attachment 1. The knowledge requirements we are establishing are those required to audit the model installation using the given audit scope <u>independent</u> of your company's audit organization.

The education and experience of the group is impressive. The descriptive profile is provided as attachment 2 for your information. Update this if appropriate. [NOTE: Profile is provided in Chapter IV.]

Please complete and return the survey as soon as possible but by June 19, if at all possible. If you have any questions, do not hesitate to call me at (513) 529-7343.

Sincerely,

Donald L. Dawley
Researcher

DLD/jr

Enclosures

PHASE II SURVEY PROCEDURE

1. Review and use the audit scope enclosed. Since the study results will be generalized (not reflect upon your firm) it is important that a generally known and accepted audit scope be used to establish the knowledge requirements.

2. Review the hypothesized current technology computer installation model enclosed. This should be used for the same reasons given for the audit scope. It is not a typical system but does represent the capabilities and vulnerabilities of current technology based systems. The use of the model does not preclude a knowledge item from being judged important on the basis of required professional knowledge.

3. Make second judgments on knowledge items after reflecting on any insights gained since Phase I and considering the group statistics.

4. Compare your second judgment to the group mean. If your assigned value is more than the mean plus one, or less than the mean minus one, briefly outline your rationale so that it can be shared anonymously with the other participants during Phase III.

NOTE: As you will notice, the group mean, high value, low value and standard deviation have been provided for the Phase I evaluations. The standard deviation is provided because it gives useful information on the spread of values around the mean. Specifically, the range of values obtained from adding and subtracting the standard deviation to/from the mean will account for roughly 68% of the evaluations.

A. If the value you assigned an item is higher than the mean plus the standard deviation, it is likely that your ranking of the item is higher than 80% of the group.

B. If the value you assigned an item is lower than the mean minus the standard deviation, it is likely that your ranking of the item is lower than 80% of the group.

SHARED RATIONALE

Identify the question AREA, NUMBER and LETTER (if applicable)

APPENDIX G

THE PHASE III COVER LETTER, INSTRUCTIONS, AND RELEASE FORM

Date

Name/Address

Dear:

Thank you for the fine effort in Phase II. Sufficient responses have been received and processed to start Phase III. The shared rationale has been inserted into the questionnaire for your thoughtful consideration. You will note that a few did not provide rationale where required and others provided rationale in a few cases where it was not required. A data entry description has been added to the model installation.

The final phase is extremely important so be sure to keep an open mind when reviewing the group statistics and the shared rationale. A few comments still reflect a company perspective rather than the internal audit profession. Please review the attached guidance and procedure carefully before completing Phase III.

Thank you for taking the time to go through this Delphi survey process. I hope you have found it to be interesting and stimulating. Please return the surveys as early as possible, but no later than the end of the month.

You will receive a summary of the research results sometime in September.

Sincerely,

Donald L. Dawley
Researcher

Enclosure

PHASE III SURVEY GUIDANCE AND PROCEDURES

1. Review and use the enclosed audit scope and hypothesized model computer installation.

   REMEMBER, the study results are to reflect the DP knowledge requirements for the internal audit profession.

   COMMENT: Your judgments should reflect the knowledge required to fulfill the audit responsibility without regard to the use of specialist.

3. Make final judgments on all knowledge items where group statistics are provided.

   COMMENT: The major area and major questions (where there are subquestions) need not be the mean of the subquestions falling under it, unless all items are given the same level of importance. The use of the mean would only be correct if the subquestions were collectively exhaustive and of equal importance.

RESTRICTED

Your individual responses will be treated confidentially. Only the group results will be released and published.

THE PHASE III SURVEY INSTRUMENT
FOR
DETERMINING THE DATA PROCESSING KNOWLEDGE AREAS FOR AUDITORS RESPONSIBLE FOR AUDITING CURRENT TECHNOLOGY COMPUTER SYSTEMS

Name ______________________________

Title ______________________________

Organization:

____

Date ______________________________

```
**********************************************************
*I would like to acknowledge the participation of you and *
*your company in this study.  If this is satisfactory,    *
*please indicate below.                                   *
*                                                         *
*       Use your name           Yes _____  No _____       *
*                                                         *
*       Use company name        Yes _____  No _____       *
*                                                         *
****This permission is for use of names only and does not *
*   alter confidentiality of individual responses. Neither *
*   your name nor the name of your firm will be used with- *
*   out your permission.                                  *
**********************************************************
```

Please refer any questions to: Donald L. Dawley
Department of Production
and Decision Sciences
Miami University
Oxford, Ohio 45056
Telephone: (513) 529-7343

APPENDIX H

INTERNAL AUDIT RESULTS FROM PHASE I

PHASE II INTERNAL AUDITOR KNOWLEDGE QUESTIONNAIRE
(Phase I Results)

Area/Item Knowledge Description	Low Value	High Value	Std Dev	Mean	Importance
AREA I: Hardware - Knowledge of equipment in use, their functions and operating concepts	1	3	.71	2.00	
1. Major types of computers -- general knowledge	1	5	1.03	2.76	
A. Analog	2	6	1.46	4.53	
B. Digital	1	5	1.03	2.76	
2. Major types of digital computers -- general knowledge	1	4	.72	2.47	
A. Micro	2	6	1.01	3.53	
B. Mini	2	4	.61	2.65	
C. Conventional	1	4	.72	2.47	
3. Different computer configurations -- general knowledge	1	3	.64	1.82	
A. Stand alone -- no remote I/O	2	6	1.20	2.76	
B. Central -- remote on-line I/O	1	6	1.11	2.12	
C. Distributed networks	1	3	.60	1.88	
4. Types of operating systems -- general knowledge	1	3	.64	2.18	
A. No operating system -- operator controlled	1	6	1.71	3.94	
B. Sequentially scheduled	2	6	1.46	3.35	
C. Multiprogramming	1	3	.72	2.47	
D. Multiprocessing	1	6	1.17	2.65	
E. Virtual	1	6	1.22	2.65	
F. Emulation	2	6	1.34	4.06	
5. Types of storage mediums in use -- general knowledge	1	4	.94	2.59	
A. Primary memory -- core, semiconductor, . . .	1	5	.97	3.24	
B. Secondary memory - tape, disk,	1	4	.94	2.53	
6. I/O and storage devices -- general knowledge	1	3	.78	2.12	
A. Printers	2	4	.56	3.24	

B. Tape drives	2	4	.70	2.88
C. Disk drives	1	4	.81	2.82
D. Mass storage units	1	5	.93	2.88
E. Readers -- card, MICR, OCR, . . .	2	6	.94	3.53
F. Card punches	2	6	1.01	3.82
G. Intelligent terminals	1	3	.70	2.12
H. Microfilm	2	6	1.15	3.76
I. CRTs	1	5	1.07	2.47
J. Keyboards	2	6	.99	3.12
K. Point-of-sale	1	4	.94	2.41
L. Audio	2	6	1.33	4.41
M. Converters	2	6	1.22	4.00
7. Communications -- general knowledge	2	5	.87	2.59
A. Modems/data sets	2	5	.87	3.53
B. Line controllers	2	6	1.00	3.65
C. Multiplexers/selector channels	2	5	.93	3.65
D. Concentrators	2	5	.92	3.71
E. Types of channels	2	6	.99	3.88
F. Front-end processors	2	5	.93	3.12
G. Cryptographic devices	2	6	1.13	3.18
8. Hardware related code structures -- general knowledge	1	6	1.47	3.18
A. Hollerith	2	6	1.22	4.35
B. ASCII codes	2	6	1.20	3.94
C. EBCDIC	1	6	1.45	3.29
D. BCD	2	6	1.13	4.18
E. BAR codes	3	6	1.05	4.29
9. Punched card accounting equipment -- general knowledge	2	6	1.06	3.59
A. Keypunch	2	6	.99	3.71
B. Verifier	2	6	1.06	3.65
C. Sorter	3	6	.88	4.18
D. Interpreter	3	6	.92	4.29
E. Reproducing punch	3	6	.80	4.41
10. Hardware related techniques -- general knowledge	2	6	1.05	3.12
A. Parity	2	6	1.01	3.53
B. Buffering	2	6	.94	3.47
C. Modularity	2	6	1.01	3.53
D. Protocols	2	6	1.00	3.65
E. Acknowledgement	2	6	1.07	3.53
F. Packet switching	2	6	.93	3.88
11. Specialized systems -- general knowledge	1	6	1.28	2.59

A. Data entry	1	6	1.23	2.47
B. Word processing	2	6	1.33	3.41
12. The operation of components together as a system	1	3	.70	1.88
A. Data transmission	1	3	.56	2.24
B. Data control	1	5	1.03	2.06
C. Data manipulation	1	3	.61	2.00
13. Security and control features -- general knowledge	1	2	.33	1.12

AREA II: Software -- general knowledge	1	3	.62	1.53
1. Available languages -- significant features and operating concepts	1	3	.66	1.94
A. High level	1	3	.60	2.12
B. Data base management system	1	3	.56	2.06
C. Specialized inquiry/report generation	1	4	.80	2.41
D. Special purpose	2	6	1.17	3.12
E. Modeling/simulation	2	6	1.29	3.82
2. Language classifications - significant features and operating concepts	2	5	.86	3.35
A. Machine/PAL/HLL/natural	2	6	1.22	3.88
B. Procedural/non-procedural	2	5	.87	3.47
3. Types of programs - general knowledge	1	3	.64	1.82
A. Application	1	3	.64	1.82
B. Utility	1	3	.60	2.12
C. Operating system	1	4	.79	2.35
D. Translator	1	6	1.27	3.35
4. Understand and evaluate the software interfaces of	1	3	.69	1.71
A. Application programs	1	3	.73	1.82
B. DBMS	1	3	.79	2.00
C. Distributed systems	1	3	.86	2.12
D. Electronic funds transfer system	1	6	1.98	3.18
E. Electronic mail systems	1	6	1.83	3.88
5. Understand programming techniques -- top down, modular, structured . . .	1	6	1.30	2.94
6. Operation of the major types of DBMS	1	5	.94	2.59

A. Modification of operating system	1	5	.99	2.71
B. Interfaces with existing OS	1	5	.99	2.71
C. Used with back-end processor	1	5	.97	3.06
7. The structure of software -- general knowledge	1	6	1.55	2.82
A. System architecture	1	6	1.46	3.41
B. Instruction formats	1	6	1.37	3.59
C. Program construction	1	6	1.49	3.29
D. Translator construction	1	6	1.25	4.06
E. Operating system structure	1	6	1.41	3.35
8. Software evaluation techniques	1	6	1.29	2.82
9. Software trends	1	5	.99	3.29
10. Available packaged software	1	4	.78	3.12
A. Vendors	1	4	.75	3.06
B. User groups	1	4	.83	3.06
AREA III: Systems Analysis and Design -- general knowledge	1	2	.44	1.24
1. Systems development methodologies -- top down, bottom up . . .	1	5	1.07	2.53
2. Systems study procedures - general knowledge	1	3	.72	1.53
A. Project origination and approval	1	5	1.03	2.06
B. Problem definition/documentation	1	5	1.06	2.00
C. Feasibility study	1	5	1.06	2.35
D. Systems study	1	4	1.00	2.41
E. Systems development	1	3	.78	2.12
F. Systems testing	1	3	.79	1.65
G. Systems implementation methods	1	4	.87	2.00
H. Conversion techniques	1	4	1.05	2.12
I. Systems/program maintenance	1	3	.75	1.94
3. Ability to design a simple system	1	4	.80	2.41
A. Batch	1	4	.86	2.35
B. On-line -- few interfaces	1	4	.80	2.47
4. Programming process from authorization to maintenance	1	4	.83	2.06
5. Able to program	1	6	1.22	2.00
A. Program assembly language	1	6	1.32	4.00
B. High level language	1	6	1.25	2.24

C. DBMS language	1	6	1.34	3.06
D. Modeling/mathematical language	1	6	1.20	4.06
E. At least one language	1	6	1.46	2.65
6. Able to understand and evaluate the design and use of	1	3	.70	1.88
A. Forms and reports	1	3	.83	2.06
B. Multiple organization systems	1	3	.64	2.18
C. Special files — libraries, indices, tables	1	3	.56	2.24
D. Coding systems	2	6	1.22	3.00
E. Multimode processing systems	1	5	1.12	3.00
F. Recovery/restart procedures	1	3	.61	2.00
G. Operating systems	1	3	.72	2.47
7. File organizations -- general knowledge	1	3	.64	1.82
A. Sequential	1	3	.61	2.00
B. Index sequential	1	3	.56	2.06
C. Random processing, non-integrated files	1	4	.73	2.18
D. Integrated data base — batch processing	1	4	.78	2.12
E. Integrated data base -- real-time processing	1	3	.61	2.00
F. Shared files	1	3	.75	1.94
G. Special reports files	1	4	.80	2.53
H. Operating system records/files	1	6	1.10	2.71
8. File access techniques — general knowledge	1	4	.94	2.41
A. Sequential	1	4	.87	2.53
B. Index sequential	1	4	.77	2.71
C. Direct	1	4	.86	2.65
D. Indices	1	5	1.09	2.76
9. Diagnostic aids - general knowledge	1	5	1.09	3.24
A. Software monitors	1	5	1.09	3.24
B. Hardware monitors	1	5	1.05	3.29
10. Computer applications -- general knowledge	1	3	.69	1.71
A. Range of applications	1	4	.87	2.00
B. Decision support techniques — models/simulation	1	6	1.35	3.24
C. Specialized applications	1	6	1.11	2.35
a. Electronic funds transfer	1	6	1.67	3.18
b. Production -- data acquistion	1	6	1.10	2.29
c. Electronic mail	1	6	1.61	3.71

11. Types of documentation -- general knowledge	1	3	.62	1.47
A. Program	1	4	.81	1.82
B. System	1	3	.62	1.47
C. Data processing operations	1	3	.70	1.65
D. User	1	3	.62	1.59
12. General categories of charts -- general knowledge	1	4	.66	2.24
A. Activity	1	4	.87	2.47
B. Layout	1	5	1.12	2.59
C. Personal/organizational relationships	1	4	.86	2.35
D. Statistical	2	5	.90	2.94
13. Specific types of charting -- general knowledge	1	3	.79	1.65
A. Program logic	1	4	1.07	2.47
B. Hierarchical input, processing, and output	1	4	.97	2.24
C. Systems flowchart	1	3	.71	1.59
D. Process flowcharts	1	4	.90	1.76
E. Gantt	1	5	1.17	3.00
14. Solution alternatives -- understand and evaluate	1	4	.78	2.12
A. Types/sizes of computers	1	5	.93	2.88
B. Computer configurations	1	5	1.05	2.71
C. Software development -- in-house, contract, . . .	1	4	.83	2.24
D. Special services -- vendor	1	5	1.05	2.71
E. Time sharing, purchase, lease .	1	5	1.06	2.59
15. Control techniques -- understand and evaluate	1	2	.33	1.12
A. Access to facilities, hardware, software, and data	1	3	.53	1.18
B. Input -- hardware, software, and procedural	1	3	.61	1.35
C. Processing	1	3	.53	1.18
a. Application programs	1	3	.56	1.24
b. Utility programs	1	3	.62	1.53
c. Operating system	1	3	.88	1.82
d. Special applications	1	2	.49	1.35
(1). Time sharing - 3rd party	1	3	.62	1.53
(2). DBMSs	1	2	.49	1.65
(3). Communication networks	1	3	.66	1.76
(4). Error correction	1	2	.47	1.29

D. Systems analysis, design, and implementation	1	3	.62	1.53
E. Documentation	1	3	.72	1.53
F. Output	1	3	.71	1.59
AREA IV: Data Processing Operations (DP & Departments)	1	3	.59	1.71
1. Tape management/control	1	3	.64	2.18
2. Forms management/control	1	4	.86	2.65
3. Data base administration	1	3	.66	2.06
4. Data entry procedures -- general knowledge	1	3	.73	1.82
A. Access	1	3	.75	1.76
B. Machine readable documents	1	6	1.10	2.71
C. Off-line manual recording	1	6	1.18	2.53
D. Scheduled on-line manual recording	1	3	.78	2.12
E. Event driven on-line manual recording	1	3	.78	2.12
F. Automatic on-line recording	1	3	.73	1.82
5. Processing modes -- host and timesharing -- general knowledge	1	4	.90	1.94
A. Card oriented batch	1	6	1.60	3.06
B. Keyboard oriented batch	1	6	1.23	2.41
C. Interactive computing	1	4	.70	2.12
D. On-line inquiry	1	4	.83	2.06
E. Data acquisition and control	1	4	.90	1.94
6. Data transmission -- general knowledge	1	4	.95	2.18
A. Data conversion	1	5	1.09	2.76
B. Transmission	1	6	1.29	2.82
C. Data control	1	4	.97	2.06
7. Processing concepts -- general knowledge	1	4	.83	2.06
A. Program loading	2	5	.93	3.35
B. File loading	2	5	.99	3.29
C. Instruction execution	2	5	.92	3.29
D. Program and record fixes	1	4	.79	2.35
E. Recovery/restart	1	4	.79	2.00

AREA V: Data Processing Management -- general knowledge	1	2	.51	1.41
1. Personnel management -- understand and evaluate	1	4	.87	2.41
A. Staffing	1	4	1.03	2.94
B. Evaluation	1	5	1.05	2.88
C. Scheduling	1	5	1.01	2.47
D. Training	1	5	.93	2.88
2. Organizational management -- understand and evaluate	1	2	.51	1.41
A. Data processing organizational structure	1	3	.75	1.94
B. Relationships with other departments	1	3	.73	1.82
C. Separation of responsibility	1	2	.49	1.35
3. Facilities management -- understand and evaluate	1	2	.51	1.53
A. Environment	1	3	.64	1.82
B. Access control	1	2	.51	1.47
4. DP operations management -- understand and evaluate	1	3	.72	1.53
A. Systems development/control	1	3	.85	1.71
B. Programming development, maintenance, and control	1	3	.78	1.88
C. Job scheduling	1	4	.86	2.35
D. Charge-back methods	1	6	1.22	2.88
E. Planning	1	5	1.06	2.59
F. Records management -- retention and control	1	3	.61	2.00
a. Forms	1	4	.77	2.29
b. Reports	1	3	.73	2.18
c. Source documents	1	3	.60	2.12
5. General knowledge of trends	1	4	.87	2.59
A. Software	1	4	.87	2.59
B. Hardware	1	4	.83	2.94
C. Systems development	1	4	.80	2.59
D. Applications	1	4	.87	2.53
E. Programming techniques	1	4	.86	2.88
6. Evaluation and contracting for	1	6	1.24	2.82
A. Software	1	6	1.25	2.76
B. Hardware	1	6	1.17	3.00

C. Consultants	1	6	1.30	2.94
7. Implications of	1	5	1.07	2.53
A. In-house versus out-house software development	1	5	1.07	2.53
B. Purchase versus lease/rental	1	5	1.11	2.65
C. In-house versus contract installation management	1	6	1.38	2.82
8. Current laws and regulations -- general knowledge	1	3	.71	1.59
A. Privacy	1	4	.88	1.82
B. Reporting requirements	1	3	.73	1.82
C. Trade secrets, patents, and copyright	1	4	.97	2.06
AREA VI: Specialized Audit Knowledge and Techniques. General knowledge of area.	1	3	.72	1.47
1. Understand and be able to use	1	3	.69	1.71
A. Test decks	1	4	.90	2.06
B. Test data generators	1	4	.87	2.59
C. Tagging and tracing	2	4	.70	2.65
D. Integrated test facility	1	4	.94	2.59
E. Live on-line sampling techniques	1	3	.75	2.06
F. Logic tracing software packages	2	4	.66	3.06
G. Code review and comparison	1	6	1.18	2.53
a. Application programs	1	6	1.16	2.71
b. Utility programs	1	6	1.25	3.06
c. Operating system programs	2	6	1.12	3.47
H. Flowcharting software packages	1	6	1.23	3.47
I. Data/record retrieval using utility programs	1	4	.88	2.18
J. DBMS data/record retrieval	1	3	.66	1.94
K. Parallel simulation	1	5	.97	2.76
L. Generalized audit software	1	4	.87	1.59
M. Ability to program custom audit software	1	5	1.13	2.18
2. Understand computer internal control/vulnerabilities	1	3	.62	1.41
A. Hardware	1	4	.88	2.18
B. Software	1	3	.62	1.53
C. Organizational	1	3	.71	1.59
D. DP procedures	1	3	.80	1.59
E. User procedures	1	3	.72	1.53
F. Systems design, development and implementation	1	3	.71	1.59

G. Documentation	1	3	.62	1.47	
H. Forms	1	3	.90	2.06	
I. Data entry	1	3	.79	1.65	

APPENDIX I

INTERNAL AUDIT RESULTS FROM PHASE II

PHASE III INTERNAL AUDITOR QUESTIONNAIRE
(Phase II Results)

Area/Item Knowledge Description	Low Value	High Value	Std Dev	Mean	Importance
AREA I: Hardware - Knowledge of equipment in use, their functions and operating concepts	2	3	.41	2.20	
Shared Rationale: Due to constant change in technology only a general knowledge can be expected.					3
1. Major types of computers--general knowledge	2	5	.83	2.87	
Shared Rationale: The distinction between analog and digital computers is rarely made in an audit environment. Very seldom would an auditor encounter the use of an analog computer. Therefore, the distinction is of little importance					4
A. Analog	2	6	1.25	4.47	
Shared Rationale: Is more important than mean indicated because real-time systems often involve analog measured feedback					2
Shared Rationale: Important because micros are often used in manufacturing distributed systems. Their functions include controlling energy demand, machine functions and other measurement functions.					3
Shared Rationale: Very seldom would an auditor encounter an analog computer.					6
Shared Rationale: The major computer vendors market digital systems--analog systems are not relevant.					5
B. Digital	2	4	.80	2.73	
Shared Rationale: It is nice to know information that is not required for EDP audit work					4
Shared Rationale: (see 1. above)					6
2. Major types of digital computers -- general knowledge	1	4	.83	2.60	
Shared Rationale: (applies to 2. and all sub-items) This knowledge is not important to the understanding of computers and the distinction is not important to auditors.					4
A. Micro	1	5	1.06	3.40	
Shared Rationale: These computers are an important part of an increasing number of distributed processing networks					1
B. Mini	1	4	.83	2.53	
C. Conventional	1	3	.68	2.20	
3. Different computer configurations -- general knowledge	1	4	.72	2.03	

A. Stand alone -- no remote I/O	1	4	.83	2.53	
Shared rationale: Important because of the increasing use for on-site batch, low priority processing, and large jobs.					2
Shared Rationale: Unimportant business applications today employ remote I/O processing.					4
B. Central -- remote on-line I/O	1	3	.64	1.87	
C. Distributed networks	1	3	.59	1.73	
4. Types of operating systems -- general knowledge	2	4	.63	2.60	
A. No operating system -- operator controlled	2	6	.96	3.93	
Shared Rationale: The majority of operating systems in use in business are multiprocessors using virtual storage concepts. The only application of knowledge could be in micro or some mini computers. The simple nature of these types of operating systems does not require full knowledge of their capabilities.					5
Shared Rationale: Not encountered in this day and age to any great degree. Concept not hard to imagine. Most auditors would have little trouble with this concept. Usually will be with conventional computer installation where some type of automated scheduling, management technique is employed.					6
B. Sequentially scheduled	2	5	.98	3.33	
Shared Rationale: Still a lot of machines like this in the inventory--especially mini and most micro's.					4
Shared Rationale: Same as 4.A. The majority of operating					5
Shared Rationale: Same as 4.A. Not encountered in this....					6
C. Multiprogramming	1	4	.82	2.67	
D. Multiprocessing	1	4	.72	2.67	
E. Virtual	1	4	.82	2.67	
F. Emulation	4	6	.64	4.53	
5. Types of storage mediums in use -- general knowledge	2	4	.68	2.80	
A. Primary memory -- core, semiconductor, . . .	2	5	.99	3.53	
Shared Rationale: May be a factor in how various applications are/or should be supported. Also how memory works from standpoint of control weaknesses i.e., in CICS you can examine core and bypass security.					3
B. Secondary memory - tape, disk,	2	4	.70	2.73	
6. I/O and storage devices -- general knowledge	2	5	.74	2.87	
A. Printers	2	5	.74	3.47	
B. Tape drives	2	4	.65	3.00	
Shared Rationale: (also applies to 6. C,D,H,K & L) A detailed knowledge of the various peripherals and options is not considered essential.					4
C. Disk drives	2	4	.59	2.93	

Shared Rationale: (see 6.B.)					4
D. Mass storage units	2	4	.65	3.00	
Shared Rationale: (see 6.B.)					4
E. Readers -- card, MICR, OCR, . . .	2	5	.74	3.47	
Shared Rationale: Important due to their wide use in point of sale systems.					2
F. Card punches	3	6	.76	4.00	
G. Intelligent terminals	2	3	.46	2.27	
H. Microfilm	3	6	.86	3.80	
Shared Rationale: (see 6.B.)					5
I. CRTs	2	3	.51	2.60	
J. Keyboards	2	6	.91	3.40	
K. Point-of-sale	1	4	.94	2.80	
Shared Rationale: (see 6.B.)					4
L. Audio	3	6	.90	4.67	
Shared Rationale: (see 6.B.)					6
Shared Rationale: Not widely used.					6
M. Converters	3	6	.80	4.07	
Shared Rationale: Not an important control feature.					5
7. Communications -- general knowledge	1	4	.68	2.80	
Shared Rationale: (applies to 7. and all sub-items) Frequent and high volumes of critical and sensitive company information is transmitted over distributed communications networks.					1
A. Modems/data sets	1	4	.80	3.27	
B. Line controllers	1	4	.77	3.20	
C. Multiplexers/selector channels	2	4	.63	3.40	
D. Concentrators	2	5	.74	3.47	
E. Types of channels	2	5	.70	3.73	
F. Front-end processors	1	4	.74	3.13	
G. Cryptographic devices	1	6	1.18	3.40	
Shared Rationale: Do not see need for specialist skill in this situation.					6
8. Hardware related code structures -- general knowledge	2	5	.94	3.80	
Shared Rationale: (applies to No 8. and all sub-items) Internal auditors have no need for this knowledge because there is no need to review the hardware code structure or the debugging of the operating system.					5
Shared Rationale: (applies to A,B,D and E below) A general knowledge of hardware related code structure is not necessary.					5
A. Hollerith	3	6	.77	4.20	
B. ASCII codes	3	6	.85	4.00	
Shared Rationale: More important because most terminals use the ASCII code.					3
C. EBCDIC	2	5	.83	3.53	
D. BCD	3	6	.74	4.13	
E. BAR codes	2	6	.96	3.93	
Shared Rationale: More important because of the wide and increasing use in point of sale systems.					3

9. Punched card accounting equipment — general knowledge	3	5	.56	3.80	
Shared Rationale for 9. and all sub-items: Still useful—becoming less important					3
A. Keypunch	3	5	.70	3.73	
B. Verifier	3	5	.68	3.80	
C. Sorter	3	5	.59	4.27	
D. Interpreter	3	6	.72	4.33	
E. Reproducing punch	3	6	.72	4.33	
10. Hardware related techniques — general knowledge	2	5	.74	3.40	
Shared Rationale: (applies to 10. and all sub-items) These are all techniques that are basic to an understanding of how computers operate. They must also be understood to talk intelligently with data processing people.					3
Shared Rationale: (applies to 10. and all sub-items) A knowledge of controls over parity, buffering, switching, etc., is required in order to properly measure needed application controls.					3
A. Parity	2	5	.94	3.20	
Shared Rationale: A basic hardware control that must be understood.					2
Shared Rationale: See 10. A knowledge of controls over					2
B. Buffering	2	5	.74	3.47	
Shared Rationale: See 10. A knowledge of controls over					3
C. Modularity	2	5	.83	3.53	
Shared Rationale: See 10. A knowledge of controls over					3
D. Protocols	2	5	.83	3.47	
Shared Rationale: See 10. A knowledge of controls over					3
E. Acknowledgement	2	5	.90	3.33	
Shared Rationale: A basic hardware control that must be understood.					2
Shared Rationale: See 10. A knowledge of controls over					2
F. Packet switching	2	5	.83	3.60	
Shared Rationale: See 10. A knowledge of controls over					3
11. Specialized systems — general knowledge	2	4	.52	2.87	
A. Data entry	2	4	.62	2.67	
B. Word processing	2	6	1.18	3.60	
Shared Rationale: Glorified typewriters.					5
12. The operation of components together as a system	1	4	.70	2.07	
Shared Rationale: (applies to 12. and all sub-items) These areas must be understood in order to assess system vulnerabilities.					2
A. Data transmission	1	4	.74	2.13	
B. Data control	1	4	.74	2.13	
C. Data manipulation	1	4	.70	2.07	

13. Security and control features -- general knowledge	1	2	.26	1.07	
AREA II: Software — general knowledge	1	3	.59	1.93	
1. Available languages -- significant features and operating concepts	1	3	.54	2.10	
A. High level	1	3	.70	2.07	
Shared Rationale: A good understanding is necessary. Most systems now use high level languages. In application systems there are times the auditor needs to look at code; i.e., if pricing is critical, if a problem is found, the code must be reviewed to see what technique or formula was actually used.					2
B. Data base management system	1	3	.46	2.07	
Shared Rationale: Widely used to process transactions and manage the data base.					1
C. Specialized inquiry/report generation	1	3	.64	2.13	
D. Special purpose	2	4	.59	2.93	
Shared Rationale: Do not see need for specialist skill in this area.					4
E. Modeling/simulation	1	6	1.16	3.73	
Shared Rationale: Important because it is often used for tuning and testing the data base.					1
2. Language classifications - significant features and operating concepts	2	5	.83	3.47	
Shared Rationale: (applies to 2. and sub-items) This knowledge is not applied directly in an audit but is basic to an understanding of software.					2
A. Machine/PAL/HLL/natural	3	5	.70	4.07	
B. Procedural/non-procedural	2	5	.77	3.80	
3. Types of programs - general knowledge	1	3	.46	1.93	
A. Application	1	3	.59	1.73	
B. Utility	1	3	.46	2.07	
C. Operating system	1	3	.62	2.33	
D. Translator	1	4	.88	3.27	
4. Understand and evaluate the software interfaces of	1	3	.80	1.93	
Shared Rationale: (applies to 4. and all sub-items) Auditors should be able to review all interfaces to assure authorized procedures.					1
A. Application programs	1	3	.77	1.80	
B. DBMS	1	3	.70	1.93	
Shared Rationale: DBMS is the way of the future.					1

C. Distributed systems	1	3	.70	1.93	
D. Electronic funds transfer system	1	6	1.31	3.00	
Shared Rationale: Important because large sums are being transferred and the system is extremely vulnerable.					2
Shared Rationale: This knowledge is not prerequisite for audit.					6
E. Electronic mail systems	1	6	1.05	3.67	
Shared Rationale: This knowledge is not prerequisite for audit.					6
5. Understand programming techniques -- top down, modular, structured . . .	2	5	1.08	2.80	
Shared Rationale: A knowledge of programming techniques is important to provide the auditor the capability to verify that adequate controls are built in and that no codes or procedures exist to bypass edits.					2
Shared Rationale: The review of system documentation requires a good understanding of the concepts under which the system and its components are developed.					2
Shared Rationale: Important because auditors are often involved in development i.e., PRIDE.					2
6. Operation of the major types of DBMS	1	3	.62	2.33	
A. Modification of operating system	1	4	.83	2.60	
Shared Rationale: Modification of any type is of interest to the auditor because of the potential impact on accountability or controls. A familiarity with the operating system is sufficient to determine such changes.					4
B. Interfaces with existing OS	1	4	.80	2.73	
Shared Rationale: The auditor needs to know what interfaces exist, when they occur and why they occur. A familiarity with the interfaces coupled with a sufficient knowledge of software capabilities in general permits the auditor to verify proper use.					4
C. Used with back-end processor	1	4	.83	3.13	
7. The structure of software -- general knowledge	1	4	.92	2.87	
Shared Rationale: (applies to 7. and sub-items A,B,C, and E) Must be understood in order to do code review.					1
Shared Rationale: (applies to 7. and all sub-items) Auditors must have a good working knowledge of all of these areas in order to properly evaluate needed controls					3
A. System architecture	1	6	1.25	3.00	
B. Instruction formats	1	6	1.16	3.27	
C. Program construction	1	6	1.13	3.13	
D. Translator construction	2	6	.96	4.07	
Shared Rationale: No audit need for this knowledge.					6
E. Operating system structure	2	6	.96	3.27	
8. Software evaluation techniques	1	4	.96	2.73	
Shared Rationale: The auditor's concern with software applies to controls over the use and capabilities of software. The evaluation and related methodology rests with data processing					

operations. The auditor should be familiar with the techniques employed in evaluating software.					4
9. Software trends	1	4	.88	2.93	
Shared Rationale: Auditors only need general information					4
10. Available packaged software	1	4	.76	3.00	
Shared Rationale: (applies to 10. and sub-items) This is a DP responsibility, the auditor only needs general information.					4
A. Vendors	1	4	.80	3.07	
B. User groups	1	4	.83	3.13	

AREA III: Systems Analysis and Design -- general knowledge	1	2	.52	1.53	
1. Systems development methodologies -- top down, bottom up . . .	1	4	.72	2.33	
2. Systems study procedures - general knowledge	1	4	.80	1.93	
Shared Rationale: (applies to No. 2 and all sub-items) System development is an important management and control process that auditors must understand and carefully evaluate.					1
A. Project origination and approval	1	5	.94	2.20	
B. Problem definition/documentation	1	5	.94	2.20	
C. Feasibility study	1	5	.96	2.27	
D. Systems study	1	4	.82	2.33	
E. Systems development	1	3	.65	2.00	
F. Systems testing	1	3	.63	1.60	
G. Systems implementation methods	1	4	.85	2.00	
H. Conversion techniques	1	4	.77	2.20	
I. Systems/program maintenance	1	3	.72	1.67	
3. Ability to design a simple system	2	3	.49	2.33	
A. Batch	2	4	.63	2.40	
B. On-line -- few interfaces	2	3	.51	2.40	
4. Programming process from authorization to maintenance	1	3	.76	2.00	
Shared Rationale: Programming procedures are extremely important in verifying that programs and changes are proper and authorized.					1
Shared Rationale: The major portion of many DP budgets is spent on maintenance. There is more chance for erroneous code in maintenance changes than in new systems development due to the timing constraints on some changes. It is very important to completely understand the entire process.					1
5. Able to program	2	3	.46	2.27	

A. Program assembly language	2	6	1.07	4.00	
Shared Rationale: Important as a basis for understanding the operation of higher level languages.					2
Shared Rationale: Must be understood to the degree necessary for reviewing code.					3
Shared Rationale: It is not necessary to be able to program assembly or DBMS languages. One can understand enough about the code to review programs written by others without the capability to program. The ability to program a higher level language is important.					6
B. High level language	2	4	.59	2.27	
C. DBMS language	2	6	1.01	3.20	
Shared Rationale: The DBMS language is probably the most effective way to access and test the data maintained.					2
Shared Rationale: (the last rationale provided in 5.A. above)					6
D. Modeling/mathematical language	3	5	.55	3.97	
E. At least one language	1	3	.70	2.07	
6. Able to understand and evaluate the design and use of	1	3	.53	2.00	
A. Forms and reports	1	3	.63	2.40	
B. Multiple organization systems	1	3	.62	2.33	
C. Special files -- libraries, indices, tables	1	3	.52	2.13	
D. Coding systems	1	4	.70	2.93	
E. Multimode processing systems	1	4	.70	2.93	
F. Recovery/restart procedures	1	3	.70	1.93	
G. Operating systems	1	5	.92	2.53	
7. File organizations -- general knowledge	2	3	.35	2.13	
A. Sequential	2	4	.56	2.20	
B. Index sequential	2	4	.56	2.20	
C. Random processing, non-integrated files	2	3	.35	2.13	
D. Integrated data base -- batch processing	2	3	.26	2.07	
E. Integrated data base -- real-time processing	1	3	.46	1.93	
F. Shared files	1	3	.46	1.93	
G. Special reports files	2	3	.46	2.27	
H. Operating system records/files	2	3	.49	2.33	
8. File access techniques -- general knowledge	2	3	.46	2.27	
A. Sequential	2	5	.83	2.53	
B. Index sequential	2	4	.63	2.40	
C. Direct	2	3	.49	2.33	
D. Indices	2	4	.64	2.53	
9. Diagnostic aids - general knowledge	1	4	.82	3.33	

Shared Rationale applies to No. 9 and both sub-items: Important tools for system tuning and detection of unauthorized use, operations or coding.					1
A. Software monitors	1	4	.83	3.40	
B. Hardware monitors	1	4	.83	3.40	
10. Computer applications -- general knowledge	1	3	.59	2.07	
A. Range of applications	1	3	.53	2.00	
Shared Rationale: It is important to know about all applications in order to be able to identify the best areas to allocate the EDP audit effort.					1
B. Decision support techniques -- models/simulation	1	5	.90	3.33	
Shared Rationale: Important due to use in designing, modifying, and managing the data base--need for audit review.					1
C. Specialized applications	2	4	.56	2.80	
a. Electronic funds transfer	2	4	.70	3.07	
b. Production -- data acquisition	2	4	.64	2.53	
c. Electronic mail	3	5	.63	3.60	
11. Types of documentation -- general knowledge	1	2	.51	1.40	
A. Program	1	2	.52	1.47	
B. System	1	3	.64	1.47	
C. Data processing operations	1	2	.52	1.47	
D. User	1	3	.64	1.47	
12. General categories of charts -- general knowledge	1	3	.62	2.33	
A. Activity	1	3	.64	2.47	
B. Layout	1	3	.64	2.13	
Shared Rationale: Auditors must understand file layouts					2
C. Personal/organizational relationships	1	4	.70	2.27	
D. Statistical	2	4	.74	3.13	
13. Specific types of charting -- general knowledge	1	3	.46	1.93	
A. Program logic	1	4	.80	2.07	
B. Hierarchical input, processing, and output	1	4	.80	2.27	
C. Systems flowchart	1	3	.64	1.47	
D. Process flowcharts	1	3	.64	1.53	
E. Gantt	2	4	.74	3.13	
14. Solution alternatives -- understand and evaluate	2	3	.52	2.53	

A. Types/sizes of computers	2	4	.59	2.73	
Shared Rationale: Auditors need only be familiar with area.					4
B. Computer configurations	2	4	.59	2.73	
Shared Rationale: Auditors need only be familiar with area.					4
C. Software development -- in-house, contract. . . .	2	3	.52	2.47	
D. Special services -- vendor	2	4	.77	2.80	
Shared Rationale: Auditors need only be familiar with area.					4
Shared Rationale: (also applies to 14.E. immediately below) Authority and accountability for such services rests with DP management. The auditor should be familair with the policies being followed.					4
E. Time sharing, purchase, lease .	2	4	.74	2.60	
Shared Rationale: Auditors need only be familiar with area.					4
Shared Rationale: (Same as last rationale in 14.D. above.					4
15. Control techniques -- understand and evaluate	1	2	.35	1.13	
A. Access to facilities, hardware, software, and data	1	1	.00	1.00	
B. Input -- hardware, software, and procedural	1	2	.41	1.20	
C. Processing	1	2	.35	1.13	
a. Application programs	1	2	.35	1.13	
b. Utility programs	1	2	.46	1.27	
c. Operating system	1	2	.51	1.40	
d. Special applications	1	2	.51	1.40	
(1). Time sharing - 3rd party	1	2	.52	1.47	
(2). DBMSs	1	2	.52	1.47	
(3). Communication networks	1	2	.52	1.47	
(4). Error correction	1	2	.26	1.07	
D. Systems analysis, design, and implementation	1	2	.52	1.53	
E. Documentation	1	2	.52	1.47	
F. Output	1	2	.52	1.47	
AREA IV: Data Processing Operations (DP & Departments)	1	2	.26	1.93	
1. Tape management/control	2	3	.35	2.13	
2. Forms management/control	2	4	.64	2.53	
Shared Rationale: Little exposure.					4
3. Data base administration	1	3	.46	1.93	
Shared Rationale: The data base administration function is normally the central control over all data base applications. It is very important to completely understand this function.					1

4. Data entry procedures -- general knowledge	1	3	.46	1.93	
A. Access	1	3	.63	1.60	
B. Machine readable documents	1	3	.64	2.53	
C. Off-line manual recording	2	4	.64	2.47	
D. Scheduled on-line manual recording	1	3	.64	2.13	
E. Event driven on-line manual recording	1	3	.56	2.20	
F. Automatic on-line recording	1	3	.65	2.00	
5. Processing modes -- host and timesharing -- general knowledge	2	3	.46	2.27	
A. Card oriented batch	2	5	.93	3.00	
Shared Rationale: The auditor's concerns vary with the processing mode. To apply control criteria to any processing mode the auditor must sufficiently understand what is happening to the data. Card oriented batch processing is no less important than other modes.					2
Shared Rationale: This mode is not used by many businesses today					5
B. Keyboard oriented batch	2	5	.83	2.60	
C. Interactive computing	1	3	.46	2.07	
D. On-line inquiry	2	3	.46	2.27	
E. Data acquisition and control	1	3	.46	2.07	
Shared Rationale: The auditor must be thoroughly knowledgeable of data acquisition and control in order to render an opinion on the adequacy of internal controls overall.					1
6. Data transmission -- general knowledge	1	3	.63	2.40	
A. Data conversion	1	3	.64	2.47	
B. Transmission	1	3	.64	2.47	
C. Data control	1	3	.59	2.07	
7. Processing concepts -- general knowledge	2	3	.52	2.47	
A. Program loading	2	4	.38	3.00	
B. File loading	2	4	.38	3.00	
C. Instruction execution	2	5	.59	3.07	
D. Program and record fixes	1	3	.56	2.20	
E. Recovery/restart	1	3	.65	2.00	
Shared Rationale: This is a very critical area for a business and a good knowledge is necessary in order to be able to evaluate its adequacy.					1
Shared Rationale: Necessary to insure application system integrity					1

AREA V: Data Processing Management -- general knowledge	1	2	.46	1.73	
1. Personnel management -- understand and evaluate	2	4	.63	2.60	
A. Staffing	2	4	.74	2.87	
Shared Rationale: (applies to all sub-items) Personnel matters are the responsibility of management in data processing. The auditor's concern should only relate to a knowledge of personnel policies and practices and the impact of changes on the auditor's ability to perform his work in a timely, effective manner.					4
Shared Rationale: (applies only to sub-items A and B) Normally staffing and evaluation in data processing are line management responsibilities. Some familiarity with the area is needed.					4
B. Evaluation	2	4	.80	2.73	
C. Scheduling	2	4	.74	2.53	
D. Training	2	4	.74	2.60	
2. Organizational management--understand and evaluate	1	2	.51	1.60	
A. Data processing organizational structure	1	3	.70	1.93	
B. Relationships with other departments	1	3	.62	1.67	
C. Separation of responsibility	1	2	.51	1.40	
3. Facilities management -- understand and evaluate	1	2	.51	1.60	
A. Environment	1	3	.52	1.87	
B. Access control	1	2	.51	1.40	
4. DP operations management -- understand and evaluate	1	2	.46	1.73	
A. Systems development/control	1	3	.64	1.53	
B. Programming development, maintenance, and control	1	3	.70	1.73	
Shared Rationale: Programming procedures are extremely important in verifying that programs and changes are proper and authorized.					1
Shared Rationale: The understanding and evaluation of program maintenance and development and the control aspects is an important EDP audit function. This knowledge is essential.					1
Shared Rationale: A thorough understanding of the programming process is essential to the assessment of application system integrity.					1
C. Job scheduling	1	4	.72	2.33	
D. Charge-back methods	1	6	1.18	2.60	

Shared Rationale: The auditor should be acquainted with the method used by data processing for the equitable distribution of its costs but such methods are seldom relevant to audit responsibilities.					4
E. Planning	1	5	.90	2.33	
F. Records management -- retention and control	1	3	.70	2.07	
Shared Rationale: (also applies to 4.F.b. and F.c. below) Important because it is often a matter of law.					1
a. Forms	1	4	.74	2.40	
b. Reports	1	4	.77	2.20	
c. Source documents	1	3	.64	2.13	
5. General knowledge of trends	1	3	.64	2.53	
A. Software	1	3	.63	2.60	
B. Hardware	1	3	.62	2.67	
C. Systems development	1	3	.63	2.40	
D. Applications	1	3	.63	2.40	
E. Programming techniques	1	3	.64	2.53	
6. Evaluation and contracting for	1	5	.99	2.87	
Shared Rationale: (also applies to all sub items) The auditor should be aware of the procedures used by management in making such decisions. Relative to audit objectives, such activities as these are of minor importance.					4
A. Software	1	5	1.05	2.67	
B. Hardware	1	5	1.00	3.00	
Shared Rationale: (also applies to 6.C. immediately below) Normally the EDP auditor is not involved in these areas directly. Hardware evaluation is a specialized area and consultants are normally retained by top management.					4
C. Consultants	1	5	1.03	2.93	
7. Implications of	1	4	.74	2.47	
A. In-house versus out-house software development	1	4	.74	2.40	
B. Purchase versus lease/rental	1	4	.74	2.53	
C. In-house versus contract installation management	1	4	.74	2.60	
8. Current laws and regulations -- general knowledge	1	3	.46	1.93	
A. Privacy	1	4	.74	1.87	
B. Reporting requirements	1	3	.56	1.80	
C. Trade secrets, patents, and copyright	2	4	.62	2.33	

AREA VI: Specialized Audit Knowledge and Techniques. General knowledge of area.	1	3	.59	1.73	
1. Understand and be able to use	1	3	.52	2.13	
Shared Rationale: (also applies to all sub items--the assigned importance varies by sub-item and is provided with the sub-item) Auditors should be able to use whatever audit techniques are available during an audit. A general understanding of all these techniques is necessary in order to select the most appropriate means.					2
A. Test decks	1	3	.62	2.33	
Shared Rationale: (see text in 1. above) Assigned importance:					2
B. Test data generators	2	4	.74	2.53	
Shared Rationale: (see text in 1. above) Assigned importance:					2
C. Tagging and tracing	2	4	.63	2.40	
Shared Rationale: (see text in 1. above) Assigned importance:					2
D. Integrated test facility	2	4	.63	2.60	
Shared Rationale: (see text in 1. above) Assigned importance:					3
Shared Rationale: The problems associated with an integrated test facility make other approaches more desirable.					4
E. Live on-line sampling techniques	1	3	.68	2.20	
Shared Rationale: (see text in 1. above) Assigned importance:					3
F. Logic tracing software packages	2	4	.59	2.93	
Shared Rationale: (see text in 1. above) Assigned importance:					3
G. Code review and comparison	2	5	.86	2.80	
Shared Rationale: (see text in 1. above) Assigned importance:					2
a. Application programs	2	5	.90	2.67	
Shared Rationale: (see text in 1.) Assigned importance:					2
b. Utility programs	2	6	1.01	3.20	
Shared Rationale: (see text in 1.) Assigned importance:					2
c. Operating system programs	2	4	.64	3.47	
Shared Rationale: (see text in 1.) Assigned importance:					2
H. Flowcharting software packages	2	6	.91	3.60	
Shared Rationale: (see text in 1.) Assigned importance:					2
I. Data/record retrieval using utility programs	1	3	.56	2.20	
Shared Rationale: (see text in 1.) Assigned importance:					2
J. DBMS data/record retrieval	1	3	.53	2.00	
Shared Rationale: (see text in 1.) Assigned importance:					1
K. Parallel simulation	1	3	.62	2.67	
Shared Rationale: (see text in 1.) Assigned importance:					3
L. Generalized audit software	1	3	.64	1.47	
Shared Rationale: (see text in 1.) Assigned importance:					2
Shared Rationale: Can accomplish the same thing if proficient in a high-level language and programming.					2

M. Ability to program custom audit software	1	4	.68	2.20	
Shared Rationale: (see text in 1.) Assigned importance:					2
Shared Rationale: Hireable if needed.					4
2. Understand computer internal control/vulnerabilities	1	2	.51	1.40	
Shared Rationale: (this rationale and the assigned importance applies to 2. and all sub-items) All vulnerabilities are extremely important.					1
A. Hardware	1	3	.70	2.07	
B. Software	1	2	.52	1.47	
C. Organizational	1	3	.64	1.53	
D. DP procedures	1	2	.48	1.37	
E. User procedures	1	3	.62	1.33	
F. Systems design, development and implementation	1	2	.52	1.47	
G. Documentation	1	2	.51	1.40	
H. Forms	1	3	.80	2.07	
I. Data entry	1	3	.64	1.47	

APPENDIX J

INTERNAL AUDIT RESULTS FROM PHASE III

FINAL PHASE III INTERNAL AUDITOR RESULTS

Area/Item Knowledge Description	Low Value	High Value	Std Dev	Mean	Importance
AREA I: Hardware - Knowledge of equipment in use, their functions and operating concepts	2	3	.51	2.38	
1. Major types of computers -- general knowledge	2	4	.51	2.87	
A. Analog	2	5	.75	3.69	
B. Digital	2	4	.76	2.92	
2. Major types of digital computers -- general knowledge	2	3	.47	2.35	
A. Micro	1	4	.69	2.85	
B. Mini	2	3	.44	2.23	
C. Conventional	2	3	.44	2.23	
3. Different computer configurations --					
A. Stand alone -- no remote I/O	1	3	.63	2.31	
B. Central -- remote on-line I/O	1	3	.55	1.85	
C. Distributed networks	1	3	.69	1.85	
4. Types of operating systems -- general knowledge	2	3	.44	2.74	
A. No operating system -- operator controlled	2	5	.85	3.31	
B. Sequentially scheduled	3	5	.65	3.48	
C. Multiprogramming	2	3	.48	2.31	
D. Multiprocessing	2	3	.44	2.23	
E. Virtual	1	3	.55	2.15	
F. Emulation	2	5	.95	3.92	
5. Types of storage mediums in use -- general knowledge	2	3	.51	2.62	
A. Primary memory -- core, semiconductor, . . .	2	4	.71	3.00	
B. Secondary memory - tape, disk,	2	3	.52	2.54	
6. I/O and storage devices -- general knowledge	2	3	.51	2.52	
A. Printers	2	4	.60	3.23	
B. Tape drives	2	3	.38	2.85	
C. Disk drives	2	3	.38	2.85	

D. Mass storage units	2	4	.41	3.00
E. Readers -- card, MICR, OCR, . . .	2	4	.55	3.15
F. Card punches	1	4	.87	3.62
G. Intelligent terminals	2	3	.38	2.15
H. Microfilm	3	4	.51	3.38
I. CRTs	2	3	.51	2.62
J. Keyboards	3	4	.44	3.23
K. Point-of-sale	2	4	.66	2.54
L. Audio	1	5	1.12	4.08
M. Converters	2	5	.76	3.92
7. Communications -- general knowledge	1	3	.55	2.15
A. Modems/data sets	1	4	.83	2.77
B. Line controllers	1	4	.90	2.85
C. Multiplexers/selector channels	1	4	.86	3.08
D. Concentrators	1	4	.95	3.08
E. Types of channels	1	4	.91	3.00
F. Front-end processors	1	4	.83	2.77
G. Cryptographic devices	1	4	.80	2.85
8. Hardware related code structures -- general knowledge	3	4	.52	3.46
A. Hollerith	2	5	.64	3.92
B. ASCII codes	2	4	.60	3.77
C. EBCDIC	2	4	.66	3.46
D. BCD	1	4	.83	3.77
E. BAR codes	1	5	.95	3.92
9. Punched card accounting equipment -- general knowledge	1	4	.88	3.46
A. Keypunch	2	4	.66	3.46
B. Verifier	2	4	.66	3.46
C. Sorter	2	4	.65	3.62
D. Interpreter	2	5	.73	3.77
E. Reproducing punch	2	5	.82	4.00
10. Hardware related techniques -- general knowledge	3	4	.39	3.20
A. Parity	2	4	.80	2.85
B. Buffering	2	4	.75	3.31
C. Modularity	2	4	.63	3.31
D. Protocols	2	4	.65	3.38
E. Acknowledgement	2	4	.80	3.15
F. Packet switching	2	4	.77	3.38
11. Specialized systems -- general knowledge	2	3	.51	2.62
A. Data entry	2	3	.51	2.38
B. Word processing	2	5	.83	3.23

12. The operation of components together as a system	2	2	.00	2.00
A. Data transmission	2	2	.00	2.00
B. Data control	1	2	.38	1.85
C. Data manipulation	1	2	.28	1.92
13. Security and control features -- general knowledge	1	3	.55	1.15

AREA II: Software -- general knowledge	2	2	.00	2.00
1. Available languages -- significant features and operating concepts	1	2	.28	1.92
A. High level	1	2	.28	1.92
B. Data base management system	1	3	.41	2.00
C. Specialized inquiry/report generation	1	3	.49	1.92
D. Special purpose	2	3	.52	2.54
E. Modeling/simulation	1	4	1.01	3.23
2. Language classifications - significant features and operating concepts	1	4	.97	3.15
A. Machine/PAL/HLL/natural	1	5	.95	3.69
B. Procedural/non-procedural	1	4	.87	3.38
3. Types of programs - general knowledge	1	2	.43	1.74
A. Application	1	2	.52	1.54
B. Utility	1	3	.49	1.92
C. Operating system	2	3	.28	2.08
D. Translator	1	4	.80	3.15
4. Understand and evaluate the software interfaces of	1	2	.37	1.84
A. Application programs	1	2	.51	1.62
B. DBMS	1	3	.43	1.96
C. Distributed systems	1	3	.41	2.00
D. Electronic funds transfer system	2	3	.51	2.62
E. Electronic mail systems	2	4	.75	3.31
5. Understand programming techniques -- top down, modular, structured . . .	2	3	.52	2.46
6. Operation of the major types of DBMS	1	3	.60	2.23
A. Modification of operating system	2	3	.48	2.35
B. Interfaces with existing OS	2	3	.52	2.46

C. Used with back-end processor	1	4	.73	2.77
7. The structure of software -- general knowledge	2	3	.51	2.62
A. System architecture	1	3	.65	2.62
B. Instruction formats	1	4	.73	2.77
C. Program construction	2	3	.48	2.69
D. Translator construction	1	6	1.27	3.54
E. Operating system structure	2	4	.52	2.96
8. Software evaluation techniques	2	3	.51	2.62
9. Software trends	2	4	.50	2.90
10. Available packaged software	2	4	.49	2.92
A. Vendors	2	4	.41	3.00
B. User groups	2	4	.41	3.00
AREA III: Systems Analysis and Design -- general knowledge	1	3	.66	1.54
1. Systems development methodologies -- top down, bottom up . . .	1	3	.58	2.00
2. Systems study procedures - general knowledge	1	2	.48	1.69
A. Project origination and approval	1	3	.55	1.85
B. Problem definition/documentation	1	3	.55	1.85
C. Feasibility study	1	3	.49	1.92
D. Systems study	1	3	.60	1.77
E. Systems development	1	3	.55	1.85
F. Systems testing	1	3	.65	1.38
G. Systems implementation methods	1	3	.55	1.85
H. Conversion techniques	1	3	.64	1.92
I. Systems/program maintenance	1	3	.66	1.54
3. Ability to design a simple system	2	3	.38	2.18
A. Batch	2	3	.48	2.31
B. On-line -- few interfaces	2	3	.48	2.31
4. Programming process from authorization to maintenance	1	2	.51	1.62
5. Able to program	2	3	.44	2.23
A. Program assembly language	2	6	1.04	3.62
B. High level language	2	3	.37	2.17
C. DBMS language	2	4	.58	3.02
D. Modeling/mathematical language	1	5	1.04	3.92

E. At least one language	1	3	.49	1.92
6. Able to understand and evaluate the design and use of	1	3	.64	1.92
A. Forms and reports	1	3	.76	2.08
B. Multiple organization systems	1	3	.58	2.00
C. Special files -- libraries, indices, tables	1	3	.41	2.00
D. Coding systems	1	3	.65	2.38
E. Multimode processing systems	2	3	.51	2.62
F. Recovery/restart procedures	1	3	.69	1.85
G. Operating systems	2	3	.38	2.15
7. File organizations -- general knowledge	2	2	.00	2.00
A. Sequential	2	3	.28	2.08
B. Index sequential	2	3	.28	2.08
C. Random processing, non-integrated files	2	3	.38	2.15
D. Integrated data base -- batch processing	2	2	.00	2.00
E. Integrated data base -- real-time processing	1	2	.28	1.92
F. Shared files	1	2	.28	1.92
G. Special reports files	2	3	.28	2.08
H. Operating system records/files	2	3	.44	2.23
8. File access techniques -- general knowledge	2	3	.38	2.15
A. Sequential	2	3	.51	2.38
B. Index sequential	2	3	.51	2.38
C. Direct	2	3	.52	2.54
D. Indices	2	4	.65	2.62
9. Diagnostic aids - general knowledge	2	4	.71	3.02
A. Software monitors	2	4	.76	2.92
B. Hardware monitors	2	4	.69	3.20
10. Computer applications -- general knowledge	1	3	.41	2.00
A. Range of applications	1	3	.55	1.82
B. Decision support techniques -- models/simulation	1	4	.83	2.77
C. Specialized applications	2	3	.43	2.75
a. Electronic funds transfer	2	3	.44	2.77
b. Production -- data acquistion	2	4	.66	2.46
c. Electronic mail	2	4	.78	3.46
11. Types of documentation -- general				

knowledge	1	3	.63	1.31
A. Program	1	3	.63	1.31
B. System	1	3	.60	1.23
C. Data processing operations	1	3	.65	1.38
D. User	1	3	.65	1.38
12. General categories of charts -- general knowledge	2	3	.44	2.26
A. Activity	2	3	.52	2.54
B. Layout	2	3	.48	2.31
C. Personal/organizational relationships	2	3	.44	2.23
D. Statistical	2	3	.44	2.77
13. Specific types of charting — general knowledge	1	2	.38	1.85
A. Program logic	1	2	.28	1.92
B. Hierarchical input, processing, and output	2	2	.00	2.00
C. Systems flowchart	1	2	.48	1.31
D. Process flowcharts	1	3	.65	1.62
E. Gantt	2	5	.83	3.23
14. Solution alternatives -- understand and evaluate	2	3	.52	2.54
A. Types/sizes of computers	2	4	.49	2.92
B. Computer configurations	2	4	.49	2.92
C. Software development -- in-house, contract, . . .	2	4	.65	2.62
D. Special services -- vendor	2	4	.55	3.15
E. Time sharing, purchase, lease .	2	4	.76	2.90
15. Control techniques -- understand and evaluate	1	2	.28	1.08
A. Access to facilities, hardware, software, and data	1	2	.28	1.08
B. Input -- hardware, software, and procedural	1	2	.28	1.08
C. Processing	1	2	.38	1.15
a. Application programs	1	2	.38	1.15
b. Utility programs	1	2	.48	1.31
c. Operating system	1	2	.51	1.38
d. Special applications	1	2	.51	1.38
(1). Time sharing - 3rd party	1	2	.52	1.54
(2). DBMSs	1	2	.48	1.31
(3). Communication networks	1	2	.51	1.38
(4). Error correction	1	2	.28	1.08
D. Systems analysis, design, and implementation	1	2	.28	1.08

E. Documentation	1	2	.28	1.08
F. Output	1	2	.38	1.15
AREA IV: Data Processing Operations (DP & Departments)	1	2	.44	1.77
1. Tape management/control	1	3	.41	2.00
2. Forms management/control	2	4	.66	2.46
3. Data base administration	1	2	.47	1.65
4. Data entry procedures -- general knowledge	1	2	.28	1.92
A. Access	1	2	.52	1.46
B. Machine readable documents	2	3	.44	2.23
C. Off-line manual recording	2	3	.44	2.23
D. Scheduled on-line manual recording	2	2	.00	2.00
E. Event driven on-line manual recording	1	2	.38	1.85
F. Automatic on-line recording	1	3	.41	2.00
5. Processing modes -- host and timesharing -- general knowledge	2	2	.00	2.00
A. Card oriented batch	2	5	.85	2.69
B. Keyboard oriented batch	2	3	.44	2.23
C. Interactive computing	2	2	.00	2.00
D. On-line inquiry	2	3	.28	2.08
E. Data acquisition and control	1	2	.44	1.77
6. Data transmission -- general knowledge	1	3	.49	2.08
A. Data conversion	1	3	.69	2.15
B. Transmission	1	3	.73	2.23
C. Data control	1	3	.55	1.85
7. Processing concepts -- general knowledge	2	3	.38	2.15
A. Program loading	2	3	.44	2.77
B. File loading	2	3	.44	2.77
C. Instruction execution	2	3	.44	2.77
D. Program and record fixes	1	3	.55	2.15
E. Recovery/restart	1	3	.55	1.85
AREA V: Data Processing Management -- general knowledge	1	3	.60	1.77

1. Personnel management -- understand and evaluate	1	3	.65	2.38
A. Staffing	2	4	.76	2.92
B. Evaluation	2	4	.71	3.00
C. Scheduling	2	4	.69	2.85
D. Training	2	4	.65	2.62
2. Organizational management -- understand and evaluate	1	3	.60	1.77
A. Data processing organizational structure	1	3	.55	1.85
B. Relationships with other departments	1	3	.55	1.85
C. Separation of responsibility	1	3	.65	1.62
3. Facilities management -- understand and evaluate	1	2	.51	1.62
A. Environment	1	2	.48	1.69
B. Access control	1	2	.52	1.54
4. DP operations management -- understand and evaluate	1	2	.48	1.69
A. Systems development/control	1	3	.66	1.46
B. Programming development, maintenance, and control	1	3	.65	1.62
C. Job scheduling	1	3	.55	2.15
D. Charge-back methods	2	4	.60	2.77
E. Planning	1	3	.64	2.09
F. Records management -- retention and control	1	3	.64	2.08
a. Forms	1	3	.63	2.31
b. Reports	1	3	.49	2.08
c. Source documents	1	3	.49	2.08
5. General knowledge of trends	2	3	.52	2.54
A. Software	2	3	.52	2.46
B. Hardware	1	3	.66	2.46
C. Systems development	2	3	.52	2.46
D. Applications	1	3	.65	2.38
E. Programming techniques	2	3	.52	2.54
6. Evaluation and contracting for	2	3	.38	2.85
A. Software	2	3	.52	2.54
B. Hardware	1	4	.69	2.85
C. Consultants	2	4	.58	3.00
7. Implications of	2	3	.51	2.38

A. In-house versus out-house software development	2	3	.52	2.46
B. Purchase versus lease/rental	2	3	.51	2.62
C. In-house versus contract installation management	2	3	.51	2.38
8. Current laws and regulations -- general knowledge	1	3	.55	1.85
A. Privacy	1	3	.60	1.77
B. Reporting requirements	1	3	.55	1.85
C. Trade secrets, patents, and copyright	1	3	.55	2.15
AREA VI: Specialized Audit Knowledge and Techniques. General knowledge of area.	1	3	.60	1.77
1. Understand and be able to use	2	2	.00	2.00
A. Test decks	2	3	.44	2.23
B. Test data generators	2	4	.66	2.46
C. Tagging and tracing	2	4	.63	2.69
D. Integrated test facility	2	4	.65	2.62
E. Live on-line sampling techniques	1	4	.75	2.31
F. Logic tracing software packages	2	4	.58	3.00
G. Code review and comparison	2	4	.75	2.69
a. Application programs	2	4	.87	2.62
b. Utility programs	2	6	1.12	3.38
c. Operating system programs	2	5	.87	3.38
H. Flowcharting software packages	2	4	.76	3.43
I. Data/record retrieval using utility programs	1	3	.58	2.00
J. DBMS data/record retrieval	1	2	.38	1.85
K. Parallel simulation	2	3	.51	2.38
L. Generalized audit software	1	3	.87	1.62
M. Ability to program custom audit software	1	3	.58	2.00
2. Understand computer internal control/vulnerabilities	1	3	.63	1.35
A. Hardware	1	3	.58	2.00
B. Software	1	3	.65	1.38
C. Organizational	1	3	.69	1.85
D. DP procedures	1	3	.65	1.38
E. User procedures	1	3	.60	1.23
F. Systems design, development and implementation	1	3	.65	1.38
G. Documentation	1	3	.63	1.31
H. Forms	1	3	.69	2.15
I. Data entry	1	3	.66	1.46

APPENDIX K

EXTERNAL AUDIT RESULTS FROM PHASE I

PHASE II EXTERNAL AUDITOR KNOWLEDGE QUESTIONNAIRE
(Phase I Results)

Area/Item Knowledge Description	Low Value	High Value	Std Dev	Mean	Importance
AREA I: Hardware - Knowledge of equipment in use, their functions and operating concepts	1	3	.76	2.08	
1. Major types of computers -- general knowledge	1	6	1.21	2.85	
A. Analog	3	6	1.12	4.62	
B. Digital	1	5	1.03	2.69	
2. Major types of digital computers -- general knowledge	1	4	.88	2.54	
A. Micro	2	6	1.11	3.31	
B. Mini	2	4	.77	2.62	
C. Conventional	1	4	.88	2.46	
Different Computer Configurations	1	3	.71	2.00	
A. Stand alone -- no remote I/O	1	6	1.27	2.46	
B. Central -- remote on-line I/O	1	3	.64	2.08	
C. Distributed networks	1	4	.86	2.08	
4. Types of operating systems -- general knowledge	1	4	.78	2.46	
A. No operating system -- operator controlled	1	6	1.65	3.31	
B. Sequentially scheduled	2	5	1.01	3.23	
C. Multiprogramming	1	4	.83	2.77	
D. Multiprocessing	1	4	.85	2.69	
E. Virtual	2	4	.73	2.77	
F. Emulation	2	6	1.19	3.62	
5. Types of storage mediums in use -- general knowledge	1	5	1.17	2.77	
A. Primary memory -- core, semiconductor, . . .	2	6	1.12	3.38	
B. Secondary memory - tape, disk,	1	5	1.04	2.62	
6. I/O and storage devices -- general knowledge	1	4	.96	2.38	
A. Printers	2	5	1.14	3.15	
B. Tape drives	1	5	1.07	2.85	

C. Disk drives	1	5	1.14	2.85
D. Mass storage units	2	5	.95	2.92
E. Readers -- card, MICR, OCR, . . .	2	5	1.15	3.00
F. Card punches	2	6	1.27	3.54
G. Intelligent terminals	1	4	.85	2.31
H. Microfilm	2	6	1.50	3.62
I. CRTs	1	4	.85	2.69
J. Keyboards	2	6	1.39	3.62
K. Point-of-sale	1	4	.88	2.54
L. Audio	2	6	1.04	3.62
M. Converters	2	6	1.28	3.85
7. Communications -- general knowledge	2	4	.95	2.92
A. Modems/data sets	2	6	1.11	3.69
B. Line controllers	2	5	.77	3.62
C. Multiplexers/selector channels	2	6	1.01	3.77
D. Concentrators	2	6	.95	3.69
E. Types of channels	2	6	1.04	3.62
F. Front-end processors	1	4	.96	2.62
G. Cryptographic devices	2	6	1.12	3.08
8. Hardware related code structures -- general knowledge	1	5	1.36	3.23
A. Hollerith	2	6	1.45	3.62
B. ASCII codes	2	5	1.32	3.31
C. EBCDIC	1	5	1.42	3.23
D. BCD	2	6	1.30	3.77
E. BAR codes	2	6	1.32	4.08
9. Punched card accounting equipment -- general knowledge	2	6	1.11	3.69
A. Keypunch	2	6	1.20	3.54
B. Verifier	2	6	1.12	3.62
C. Sorter	2	6	1.14	4.15
D. Interpreter	2	6	1.04	3.92
E. Reproducing punch	2	6	1.04	3.92
10. Hardware related techniques -- general knowledge	2	5	1.24	3.23
A. Parity	1	6	1.51	3.46
B. Buffering	2	6	1.26	3.92
C. Modularity	2	6	1.26	3.92
D. Protocols	2	5	1.25	3.31
E. Acknowledgement	2	5	1.19	3.38
F. Packet switching	1	6	1.41	3.85
11. Specialized systems -- general knowledge	1	5	1.09	2.77
A. Data entry	1	5	1.09	2.77

B. Word processing	3	6	1.13	4.46
12. The operation of components together as a system	1	3	.82	2.00
A. Data transmission	1	4	.93	2.77
B. Data control	1	3	.80	1.85
C. Data manipulation	1	3	.76	1.92
13. Security and control features -- general knowledge	1	3	.78	1.46
AREA II: Software -- general knowledge	1	4	.93	1.77
1. Available languages -- significant features and operating concepts	1	4	1.01	2.23
A. High level	1	4	.83	2.23
B. Data base management system	1	4	.77	2.62
C. Specialized inquiry/report generation	1	4	.96	2.38
D. Special purpose	1	4	.83	2.77
E. Modeling/simulation	3	5	.90	3.85
2. Language classifications - significant features and operating concepts	1	6	1.26	3.92
A. Machine/PAL/HLL/natural	2	6	1.08	4.00
B. Procedural/non-procedural	1	6	1.28	3.85
3. Types of programs - general knowledge	1	4	.93	1.77
A. Application	1	4	.93	1.77
B. Utility	1	4	1.03	2.31
C. Operating system	2	4	.76	3.08
D. Translator	2	6	1.07	3.85
4. Understand and evaluate the software interfaces of	1	4	.95	1.69
A. Application programs	1	4	.96	1.62
B. DBMS	1	4	.99	1.85
C. Distributed systems	1	4	1.01	1.77
D. Electronic funds transfer system	1	4	1.08	2.00
E. Electronic mail systems	2	6	1.33	4.46
5. Understand programming techniques -- top down, modular, structured . . .	2	5	1.04	3.62
6. Operation of the major types of DBMS	2	4	.83	2.77
A. Modification of operating system	1	4	1.04	2.62

B. Interfaces with existing OS	2	4	.83	2.77
C. Used with back-end processor	2	6	1.09	3.23
7. The structure of software -- general knowledge	2	5	1.03	3.69
A. System architecture	1	5	1.25	3.69
B. Instruction formats	2	5	.86	3.92
C. Program construction	2	5	.93	3.77
D. Translator construction	4	5	.51	4.38
E. Operating system structure	2	5	1.08	4.00
8. Software evaluation techniques	1	5	1.33	3.38
9. Software trends	2	5	.97	3.46
10. Available packaged software	2	4	.55	2.85
A. Vendors	2	5	.82	3.00
B. User groups	1	6	1.28	3.15
AREA III: Systems Analysis and Design -- general knowledge	1	4	.95	2.08
1. Systems development methodologies -- top down, bottom up . . .	2	4	.69	2.85
2. Systems study procedures - general knowledge	1	4	.91	2.00
A. Project origination and approval	1	4	1.01	2.23
B. Problem definition/documentation	1	4	.99	2.15
C. Feasibility study	1	4	1.11	2.69
D. Systems study	1	4	1.04	2.38
E. Systems development	1	4	.90	2.15
F. Systems testing	1	4	.95	1.92
G. Systems implementation methods	1	4	1.07	2.15
H. Conversion techniques	1	4	1.04	2.08
I. Systems/program maintenance	1	4	1.01	2.23
3. Ability to design a simple system	1	4	.96	2.62
A. Batch	1	4	1.04	2.62
B. On-line -- few interfaces	1	4	.83	2.77
4. Programming process from authorization to maintenance	1	3	.80	1.85
5. Able to program	1	5	1.36	2.77
A. Program assembly language	2	6	1.32	4.31
B. High level language	1	6	1.57	2.85
C. DBMS language	2	6	1.26	3.62

D. Modeling/mathematical language	3	6	1.26	4.62
E. At least one language	2	6	1.28	3.85
6. Able to understand and evaluate the design and use of	1	3	.82	2.00
A. Forms and reports	1	4	.95	2.31
B. Multiple organization systems	1	4	1.20	2.54
C. Special files -- libraries, indices, tables	1	4	1.05	2.54
D. Coding systems	1	4	.86	3.08
E. Multimode processing systems	1	4	.95	3.31
F. Recovery/restart procedures	1	4	1.03	2.31
G. Operating systems	1	4	.93	2.77
7. File organizations -- general knowledge	1	4	1.08	2.00
A. Sequential	1	4	1.14	2.15
B. Index sequential	1	4	1.14	2.15
C. Random processing, non-integrated files	1	4	1.09	2.23
D. Integrated data base -- batch processing	1	4	1.03	2.31
E. Integrated data base -- real-time processing	1	4	1.04	2.08
F. Shared files	1	4	.95	2.31
G. Special reports files	1	4	.99	2.85
H. Operating system records/files	1	4	1.01	2.77
8. File access techniques -- general knowledge	1	4	1.18	2.31
A. Sequential	1	4	1.18	2.31
B. Index sequential	1	4	1.18	2.31
C. Direct	1	4	1.18	2.31
D. Indices	1	4	1.18	2.31
9. Diagnostic aids - general knowledge	2	6	1.20	3.54
A. Software monitors	2	6	1.27	3.46
B. Hardware monitors	2	6	1.14	3.85
10. Computer applications -- general knowledge	1	3	.76	1.92
A. Range of applications	1	3	.87	1.62
B. Decision support techniques -- models/simulation	2	6	1.05	3.46
C. Specialized applications	1	4	.96	2.38
a. Electronic funds transfer	1	4	.96	2.38
b. Production -- data acquistion	1	6	1.34	2.85
c. Electronic mail	3	6	1.14	4.15

11. Types of documentation -- general knowledge	1	3	.66	1.54
A. Program	1	4	.95	1.69
B. System	1	3	.77	1.62
C. Data processing operations	1	4	1.01	1.77
D. User	1	3	.75	1.69
12. General categories of charts -- general knowledge	1	4	.95	1.92
A. Activity	1	4	.96	2.38
B. Layout	1	6	1.56	2.38
C. Personal/organizational relationships	1	4	.95	1.69
D. Statistical	1	6	1.52	3.15
13. Specific types of charting -- general knowledge	1	3	.60	1.77
A. Program logic	1	5	1.19	2.92
B. Hierarchical input, processing, and output	1	4	.96	2.38
C. Systems flowchart	1	3	.65	1.62
D. Process flowcharts	1	4	1.12	2.62
E. Gantt	1	6	1.38	3.69
14. Solution alternatives -- understand and evaluate	2	6	1.29	3.00
A. Types/sizes of computers	2	6	1.18	3.31
B. Computer configurations	1	6	1.32	3.08
C. Software development -- in-house, contract, . . .	1	6	1.38	2.92
D. Special services -- vendor	2	6	1.18	3.31
E. Time sharing, purchase, lease .	2	6	1.04	3.38
15. Control techniques -- understand and evaluate	1	2	.38	1.15
A. Access to facilities, hardware, software, and data	1	3	.60	1.23
B. Input -- hardware, software, and procedural	1	3	.63	1.31
C. Processing	1	2	.28	1.08
a. Application programs	1	2	.38	1.15
b. Utility programs	1	4	1.04	1.62
c. Operating system	1	4	1.04	2.08
d. Special applications	1	4	.87	1.62
(1). Time sharing - 3rd party	1	4	.95	1.92
(2). DBMSs	1	4	1.00	2.00
(3). Communication networks	1	4	1.04	2.08
(4). Error correction	1	3	.65	1.38
D. Systems analysis, design, and				

implementation	1	4	.93	1.77
E. Documentation	1	3	.66	1.46
F. Output	1	2	.52	1.46
AREA IV: Data Processing Operations (DP & Departments)	1	3	.65	1.62
1. Tape management/control	1	4	1.00	2.00
2. Forms management/control	1	4	.85	2.69
3. Data base administration	1	4	1.00	2.00
4. Data entry procedures -- general knowledge	1	3	.75	1.69
A. Access	1	3	.63	1.69
B. Machine readable documents	1	4	.80	2.15
C. Off-line manual recording	1	4	1.09	2.23
D. Scheduled on-line manual recording	1	4	1.09	2.23
E. Event driven on-line manual recording	1	4	1.09	2.23
F. Automatic on-line recording	1	4	1.14	2.15
5. Processing modes -- host and timesharing -- general knowledge	1	3	.73	1.77
A. Card oriented batch	1	4	.97	2.46
B. Keyboard oriented batch	1	4	.83	2.23
C. Interactive computing	1	3	.86	1.92
D. On-line inquiry	1	3	.69	2.15
E. Data acquisition and control	1	3	.90	1.85
6. Data transmission -- general knowledge	1	4	1.19	2.08
A. Data conversion	1	4	.87	2.62
B. Transmission	1	4	.95	2.69
C. Data control	1	4	1.15	2.00
7. Processing concepts -- general knowledge	1	4	1.09	2.77
A. Program loading	1	4	1.04	2.92
B. File loading	1	4	1.04	2.92
C. Instruction execution	2	4	.75	3.31
D. Program and record fixes	1	4	1.11	2.69
E. Recovery/restart	1	4	1.05	2.54

AREA V: Data Processing Management -- general knowledge	1	3	.78	1.46
1. Personnel management -- understand and evaluate	1	4	.88	2.46
A. Staffing	1	4	.85	2.69
B. Evaluation	1	6	1.41	3.00
C. Scheduling	1	5	1.19	2.92
D. Training	1	5	1.11	2.69
2. Organizational management -- understand and evaluate	1	3	.65	1.38
A. Data processing organizational structure	1	3	.78	1.46
B. Relationships with other departments	1	3	.78	1.46
C. Separation of responsibility	1	3	.60	1.23
3. Facilities management -- understand and evaluate	1	3	.77	1.62
A. Environment	1	4	.99	1.85
B. Access control	1	3	.77	1.62
4. DP operations management -- understand and evaluate	1	4	.83	1.77
A. Systems development/control	1	4	.93	1.77
B. Programming development, maintenance, and control	1	4	.85	1.69
C. Job scheduling	1	4	.95	2.31
D. Charge-back methods	1	6	1.52	3.15
E. Planning	1	5	1.11	2.69
F. Records management -- retention and control	1	4	.86	1.92
a. Forms	1	5	1.33	2.62
b. Reports	1	4	1.11	2.31
c. Source documents	1	4	.90	1.85
5. General knowledge of trends	1	4	.80	2.85
A. Software	1	4	.95	2.92
B. Hardware	2	4	.73	3.23
C. Systems development	2	4	.60	3.23
D. Applications	2	4	.71	3.00
E. Programming techniques	3	4	.52	3.46
6. Evaluation and contracting for	1	5	1.05	3.46
A. Software	1	5	1.12	3.38
B. Hardware	2	5	.95	3.69

C. Consultants	2	5	.95	3.69
7. Implications of	1	5	1.18	2.69
A. In-house versus out-house software development	1	5	1.18	2.69
B. Purchase versus lease/rental	1	6	1.33	3.62
C. In-house versus contract installation management	1	5	1.38	3.31
8. Current laws and regulations -- general knowledge	1	4	.83	2.23
A. Privacy	1	6	1.24	2.77
B. Reporting requirements	1	6	1.33	2.54
C. Trade secrets, patents, and copyright	2	6	1.33	3.46
AREA VI: Specialized Audit Knowledge and Techniques. General knowledge of area.	1	4	.95	1.69
1. Understand and be able to use	1	4	1.00	2.00
A. Test decks	1	5	1.33	2.46
B. Test data generators	1	6	1.53	3.00
C. Tagging and tracing	1	6	1.61	3.08
D. Integrated test facility	1	5	1.04	2.92
E. Live on-line sampling techniques	1	4	.95	1.92
F. Logic tracing software packages	1	6	1.32	3.31
G. Code review and comparison	1	6	1.38	3.31
a. Application programs	1	6	1.38	3.31
b. Utility programs	1	6	1.17	3.77
c. Operating system programs	3	6	.93	4.23
H. Flowcharting software packages	1	6	1.20	3.54
I. Data/record retrieval using utility programs	1	4	.91	2.00
J. DBMS data/record retrieval	1	4	.95	2.31
K. Parallel simulation	1	4	1.12	2.62
L. Generalized audit software	1	3	.78	1.54
M. Ability to program custom audit software	1	5	1.30	2.23
2. Understand computer internal control/vulnerabilities	1	3	.60	1.23
A. Hardware	1	3	.93	1.77
B. Software	1	3	.78	1.46
C. Organizational	1	3	.63	1.31
D. DP procedures	1	3	.65	1.38
E. User procedures	1	3	.65	1.38
F. Systems design, development and implementation	1	3	.65	1.38

G. Documentation	1	3	.78	1.46
H. Forms	1	4	.97	2.46
I. Data entry	1	3	.78	1.54

>>

APPENDIX L

EXTERNAL AUDIT RESULTS FROM PHASE II

PHASE III EXTERNAL AUDITOR KNOWLEDGE QUESTIONNAIRE
(Phase II Results)

Area/Item Knowledge Description	Low Value	High Value	Std Dev	Mean	Importance
AREA I: Hardware - Knowledge of equipment in use, their functions and operating concepts	1	3	.62	2.07	
1. Major types of computers -- general knowledge	1	4	.80	2.79	
Shared Rationale: (applies to 1 and sub-items) Audit trails and controls are generally independent of types of hardware. The key to both a well controlled and efficient system is the software. Therefore only a generalized knowledge of hardware is necessary.					3
Shared Rationale: (also applies to A. The assigned importance for A is different and given with A) Haven't seen an analog computer in 20 years.					4
A. Analog	4	6	.74	4.64	
Shared Rationale: (see the last rationale in 1 above)					6
B. Digital	1	4	.93	2.36	
2. Major types of digital computers -- general knowledge	1	3	.65	2.43	
Shared Rationale: (applies to 2 and sub-items A and C) Micro and mini computers are becoming widely used by many small, medium, and large firms and are used with and without remote processing capability. Therefore auditors must be required to understand smaller stand-alone systems.					2
A. Micro	2	5	.83	3.29	
B. Mini	2	4	.65	2.57	
C. Conventional	1	3	.66	2.14	
3. Different computer configurations -- general knowledge	1	3	.53	2.14	
A. Stand alone -- no remote I/O	1	3	.73	2.07	
Shared Rationale: Auditors must understand all configurations of computer systems because of the increasing importance of micro and mini computers as stand-alone systems as well as components of larger distributed networks.					1
B. Central -- remote on-line I/O	1	3	.55	2.00	
C. Distributed networks	1	3	.62	1.93	
4. Types of operating systems -- general knowledge	2	3	.50	2.64	

A. No operating system -- operator controlled	2	6	1.29	3.50	
Shared Rationale: Again, a large number of businesses have small scale (mini or micro) computers that are really under control of the computer operator for processing.					2
B. Sequentially scheduled	2	5	.94	3.43	
C. Multiprogramming	1	4	.83	2.71	
Shared Rationale: (applies to C,D,and E) A general knowledge of the technical characteristics of an operating system (e.g., multiprogramming, multiprocessing, or virtual) is usually not relevant. The assessment of risk or the evaluation of control.					4
D. Multiprocessing	1	4	.84	2.64	
E. Virtual	2	4	.70	2.79	
F. Emulation	2	6	1.01	3.64	
5. Types of storage mediums in use -- general knowledge	2	3	.27	2.93	
A. Primary memory -- core, semiconductor, . . .	2	6	.93	3.36	
Shared Rationale: The engineering requirements for core storage do not have any effect on the condition of control or data. This area is not relevant from an audit standpoint.					6
B. Secondary memory - tape, disk,	2	3	.47	2.71	
6. I/O and storage devices -- general knowledge	2	3	.36	2.86	
A. Printers	2	4	.61	3.29	
B. Tape drives	2	4	.68	3.00	
C. Disk drives	2	4	.53	3.14	
D. Mass storage units	2	5	.80	3.21	
E. Readers -- card, MICR, OCR, . . .	2	4	.53	3.14	
F. Card punches	3	6	.93	3.64	
Shared Rationale: (also applies to H and M) Hardware alternatives have little or no effect on audit decisions. The I/O devices that need to be understood are those that extend "beyond the computer room" i.e., intelligent remote terminals etc., because they affect the evaluation of access controls.					6
G. Intelligent terminals	1	3	.65	2.57	
H. Microfilm	3	6	.84	3.64	
I. CRTs	1	3	.65	2.57	
J. Keyboards	1	5	1.03	3.14	
K. Point-of-sale	2	3	.50	2.64	
L. Audio	3	4	.51	3.57	
M. Converters	2	6	.91	3.71	
7. Communications -- general knowledge	2	4	.62	3.07	
A. Modems/data sets	2	4	.65	3.50	
B. Line controllers	2	5	.70	3.79	
C. Multiplexers/selector channels	2	5	.93	3.64	

Shared Rationale: (also applies to E) The types of channels used are not usually relevant to the assessment of risk or the evaluation of control.					5
D. Concentrators	2	5	.84	3.64	
E. Types of channels	2	5	.89	3.79	
F. Front-end processors	2	5	.80	2.79	
G. Cryptographic devices	2	6	1.20	3.71	
Shared Rationale: Cryptographic devices are almost never used relative to risks that are of concern to financial statement auditors.					5
Shared Rationale: Cryptographic devices are not widely used with financial systems, auditors may have to research if encountered.					6
8. Hardware related code structures -- general knowledge	2	5	.94	3.43	
Shared Rationale: (applies to 8 and all sub-items. The assigned importance varies and is provided with the sub-item) Auditors working with computers and reviewing controls should be required to be familiar with the basic code structures in order to be able to distinguish the hardware differences of various computers. This is especially important when auditors are developing computer assisted auditing procedures.					2
A. Hollerith	2	5	.85	3.57	
B. ASCII codes	2	5	.94	3.50	
C. EBCDIC	1	5	1.20	3.29	
Shared Rationale: EBCDIC knowledge is important for audit software					2
D. BCD	3	5	.74	3.64	
E. BAR codes	3	6	.95	4.14	
9. Punched card accounting equipment -- general knowledge	3	5	.61	3.71	
Shared Rationale: (applies to all sub-items) While a knowledge of punched card equipment may occasionally be useful, it has no bearing on audit evaluation.					5
A. Keypunch	2	5	.76	3.57	
B. Verifier	2	5	.73	3.71	
C. Sorter	4	6	.63	4.36	
D. Interpreter	3	5	.62	4.07	
Shared Rationale: (also applies to E) Knowledge not needed; have not seen for many years.					5
E. Reproducing punch	3	5	.53	4.14	
10. Hardware related techniques -- general knowledge	3	4	.50	3.64	
A. Parity	2	5	.76	3.57	
B. Buffering	3	6	.80	3.79	
C. Modularity	3	6	.73	3.93	
D. Protocols	2	6	.86	3.86	
E. Acknowledgement	2	6	.86	3.86	

F. Packet switching	3	6	.68	4.00	
11. Specialized systems -- general knowledge	2	4	.47	3.07	
A. Data entry	2	4	.73	2.71	
B. Word processing	3	6	.86	4.14	
12. The operation of components together as a system	2	4	.53	2.14	
A. Data transmission	2	4	.61	2.71	
B. Data control	1	5	.95	2.14	
C. Data manipulation	1	4	.66	2.14	
13. Security and control features -- general knowledge	1	4	.85	1.57	
AREA II: Software -- general knowledge	1	3	.58	1.79	
1. Available languages -- significant features and operating concepts	1	4	.84	2.36	
A. High level	1	4	.86	2.14	
B. Data base management system	1	4	.74	2.36	
C. Specialized inquiry/report generation	1	3	.74	2.36	
D. Special purpose	1	4	.73	2.71	
E. Modeling/simulation	1	5	1.01	3.64	
Shared Rationale: The external audit purpose does not often include modeling /simulation. Primary purpose is the audit attest function.					5
2. Language classifications - significant features and operating concepts	1	5	.94	3.43	
A. Machine/PAL/HLL/natural	1	5	.94	3.57	
B. Procedural/non-procedural	1	5	.94	3.50	
3. Types of programs - general knowledge	1	4	.77	1.86	
Shared Rationale: (applies to 3 and all sub-items. The assigned importance varies and is provided with the sub-item) A good general knowledge of how programs work and interface is essential to the evaluation of controls. While specifics of various vendors' operating systems may not be important, the knowledge of how application programs relate to operating systems is of utmost importance.					1
A. Application	1	3	.65	1.43	
Shared Rationale: (see 3. for rationale)					1
B. Utility	1	4	.91	1.71	
Shared Rationale: Auditors must understand the types of utility					

programs available. Utility programs can be used to copy files, delete files, change data, and change file names. In many cases the utility program provides a minimal audit trail, if any. Auditors must understand the risks involved in this area.					1
Shared Rationale: (see 3. for rationale)					1
C. Operating system	1	4	.85	2.57	
D. Translator	1	6	1.16	3.50	
Shared Rationale: (see 3. for rationale)					2
4. Understand and evaluate the software interfaces of	1	4	.77	1.86	
A. Application programs	1	3	.63	1.64	
B. DBMS	1	4	.83	1.71	
C. Distributed systems	1	4	.80	1.79	
D. Electronic funds transfer system	1	4	1.00	1.93	
Shared Rationale: If you are auditing a bank, EFTS gets a "2"; as a general knowledge item for every auditor, it is not very important.					4
E. Electronic mail systems	3	6	.83	4.29	
Shared Rationale: Not relevant.					6
5. Understand programming techniques — top down, modular, structured . . .	2	5	.91	3.29	
6. Operation of the major types of DBMS	2	4	.58	2.79	
A. Modification of operating system	1	4	.80	2.79	
Shared Rationale: (applies also to B) 99% plus of all auditors are not, and never will be, technically qualified to understand DBMS related "modification of operating system" or "interfaces with the OS"—these items are no more important than any file interface and are not relevant to risk assessment or control evaluation.					4
B. Interfaces with existing OS	1	4	.77	2.86	
C. Used with back-end processor	1	5	1.05	3.21	
7. The structure of software —	2	5	.76	3.57	
A. System architecture	2	5	.76	3.57	
B. Instruction formats	2	5	.76	3.57	
C. Program construction	2	5	.76	3.50	
D. Translator construction	3	5	.53	4.14	
E. Operating system structure	3	5	.70	3.79	
8. Software evaluation techniques	1	5	1.08	3.36	
Shared Rationale: The software evaluation process is just as important as the process for developing in-house systems. Adequate controls of a proposed software product must be considered in the software purchase decision.					2
9. Software trends	3	4	.50	3.36	

10. Available packaged software	2	4	.47	2.93	
Shared Rationale: (also applies to both sub-items) Not relevant.					4
A. Vendors	2	4	.55	3.00	
B. User groups	2	4	.47	3.07	
AREA III: Systems Analysis and Design -- general knowledge	2	3	.47	2.29	
1. Systems development methodologies -- top down, bottom up . . .	2	4	.47	2.93	
2. Systems study procedures - general knowledge	2	4	.76	2.57	
Shared Rationale: (also applies to sub-items A to E) External auditors do not need this knowledge to audit systems and provide an opinion.					4
A. Project origination and approval	2	4	.65	2.50	
B. Problem definition/documentation	2	4	.76	2.50	
C. Feasibility study	2	6	1.11	3.00	
D. Systems study	2	5	.97	2.79	
E. Systems development	2	4	.65	2.50	
F. Systems testing	1	3	.47	2.07	
G. Systems implementation methods	2	3	.52	2.50	
H. Conversion techniques	1	3	.63	2.36	
I. Systems/program maintenance	1	3	.61	2.29	
3. Ability to design a simple system	1	5	1.01	2.64	
Shared Rationale: (also applies to both sub-items) Knowledge not required to audit systems.					5
A. Batch	1	5	.99	2.71	
B. On-line -- few interfaces	1	5	.97	2.79	
4. Programming process from authorization to maintenance	1	3	.58	1.79	
Shared Rationale: If "programming process from authorization to maintenance is a "2", the auditor should "sufficiently understand to apply." Most auditors do not have to program. They only need a general knowledge (scale "3") to be able to evaluate risks and controls.					3
5. Able to program	1	5	1.23	2.86	
Shared Rationale: (also applies to sub-items A to D. Assigned importance is given with each item) External auditors do not need this knowledge.					5
A. Program assembly language	3	5	.77	4.14	
Shared Rationale: (see 5 for rationale)					5
B. High level language	1	5	1.19	2.79	
Shared Rationale: (see 5 for rationale)					5
C. DBMS language	2	5	.93	3.64	

Shared Rationale: (see 5 for rationale)					5
D. Modeling/mathematical language	3	6	.84	4.36	
Shared Rationale: (see 5 for rationale)					6
E. At least one language	1	5	1.20	3.29	
Shared Rationale: Understanding of a programming language is rudimentary to anyone in the data processing field--including auditors of computer based systems.					2
6. Able to understand and evaluate the design and use of	1	3	.47	1.93	
A. Forms and reports	1	3	.66	2.14	
Shared Rationale: (also applies to C) Forms, reports, and libraries are integrated parts of a system of internal accounting control. Lack of adequate design, control, and use of these areas could cause an otherwise adequate system to be evaluated negatively.					1
B. Multiple organization systems	2	4	.65	2.43	
C. Special files -- libraries, indices, tables	1	4	.85	2.43	
D. Coding systems	2	4	.77	2.86	
E. Multimode processing systems	2	5	.83	3.29	
F. Recovery/restart procedures	1	4	.74	2.36	
G. Operating systems	2	4	.73	2.93	
Shared Rationale: Nothing in the required scope of a financial statement audit requires an auditor to have a general knowledge Re the "evaluation of the design" of an operating system. Perhaps evaluate controls within the operating system.					4
7. File organizations -- general knowledge	1	4	.70	2.21	
A. Sequential	1	4	.80	2.21	
B. Index sequential	1	4	.80	2.21	
C. Random processing, non-integrated files	1	4	.80	2.21	
D. Integrated data base -- batch processing	1	4	.73	2.29	
E. Integrated data base -- real-time processing	1	4	.70	2.21	
F. Shared files	1	4	.74	2.36	
G. Special reports files	2	4	.63	2.64	
H. Operating system records/files	2	4	.62	2.93	
Shared Rationale: Operating systems require an in-depth technical knowledge to understand and review--this is often beyond the skill level of the auditor. If operating systems must be reviewed, it should be the job of a technical EDP specialist--not in the financial audit scope.					4
8. File access techniques -- general knowledge	1	4	.74	2.36	
A. Sequential	1	4	.74	2.36	

B. Index sequential	1	4	.74	2.36	
C. Direct	1	4	.74	2.36	
D. Indices	1	4	.76	2.43	
9. Diagnostic aids - general knowledge	3	5	.65	3.50	
A. Software monitors	1	5	.99	3.29	
Shared Rationale: A good and well used software monitor can compensate for certain other weaknesses in internal control. Auditors must understand to adequately evaluate controls.					2
B. Hardware monitors	3	5	.61	3.71	
10. Computer applications -- general knowledge	1	2	.47	1.71	
A. Range of applications	1	2	.51	1.57	
B. Decision support techniques -- models/simulation	2	5	.76	3.57	
C. Specialized applications	1	5	.94	2.50	
a. Electronic funds transfer	1	5	.94	2.43	
Shared Rationale: Not relevent to financial audits.					6
b. Production -- data acquisition	1	5	1.02	2.43	
c. Electronic mail	3	6	1.14	4.29	
11. Types of documentation -- general knowledge	1	3	.61	1.71	
A. Program	1	3	.70	1.79	
Shared Rationale: (also applies to C) Program and data processing operations documentation are generally not a very useful source of audit information. A general knowledge is usually adequate since important information (e.g. re controls) is usually available from easier to use sources.					3
B. System	1	3	.65	1.57	
C. Data processing operations	1	3	.70	1.79	
D. User	1	3	.65	1.57	
12. General categories of charts -- general knowledge	2	5	.85	2.50	
A. Activity	2	5	.86	2.86	
B. Layout	1	5	.97	2.79	
Shared Rationale: Record and file layouts are extremely important. Since the development of computer audit procedures and the review of applications are essential, this must have top priority in order for audit objectives to be achieved.					1
C. Personal/organizational relationships	1	3	.62	1.93	
D. Statistical	2	4	.61	3.29	
13. Specific types of charting -- general knowledge	1	4	.68	2.00	

A. Program logic	1	4	1.08	2.64	
B. Hierarchical input, processing, and output	1	4	.91	2.29	
Shared Rationale: Necessary for understanding the flow of transactions through the system. Top priority--most important.					1
Shared Rationale: External auditors do not need this knowledge to audit systems.					4
C. Systems flowchart	1	3	.61	1.71	
D. Process flowcharts	1	4	.84	2.36	
E. Gantt	1	5	1.09	3.43	
14. Solution alternatives -- understand and evaluate	1	5	1.04	3.00	
Shared Rationale: (applies to 14 and all sub-items. The assigned importance varies and is provided with the sub-item) Necessary for the completion of the preliminary EDP review and to estimate the resources required to complete the general controls review.					2
Shared Rationale: (applies to 14 and all sub-items) From an auditing standpoint being able to select from alternatives is not important. This is a management service function					5
A. Types/sizes of computers	1	5	1.03	3.14	
Shared Rationale: (see 14 for rationale)					2
B. Computer configurations	1	5	1.03	3.14	
Shared Rationale: (see 14 for rationale)					2
C. Software development -- in-house, contract, . . .	1	5	1.03	2.86	
Shared Rationale: (see 14 for rationale)					3
D. Special services -- vendor	1	5	1.00	3.07	
Shared Rationale: (see 14 for rationale)					3
E. Time sharing, purchase, lease.	1	5	1.03	3.14	
Shared Rationale: (see 14 for rationale)					3
15. Control techniques -- understand and evaluate	1	1	.00	1.00	
A. Access to facilities, hardware, software, and data	1	2	.27	1.07	
B. Input -- hardware, software, and procedural	1	2	.36	1.14	
C. Processing	1	1	.00	1.00	
a. Application programs	1	1	.00	1.00	
b. Utility programs	1	2	.50	1.36	
c. Operating system	1	3	.73	1.93	
Shared Rationale: External auditors do not need this knowledge. Usually assume the operating system is OK.					3
Shared Rationale: Not within the financial audit scope. Operating systems should be evaluated by a specialist rather than a computer auditor.					3
d. Special applications	1	3	.65	1.57	
(1). Time sharing - 3rd party	1	3	.66	1.86	
(2). DBMSs	1	4	.77	1.86	

(3). Communication networks	1	5	1.00	1.93	
(4). Error correction	1	4	.85	1.50	
D. Systems analysis, design, and implementation	1	2	.52	1.50	
E. Documentation	1	4	.93	1.64	
Shared Rationale: Documentation is not that important.					4
F. Output	1	2	.43	1.21	
AREA IV: Data Processing Operations (DP & Departments)	1	3	.61	1.71	
1. Tape management/control	1	3	.80	1.79	
2. Forms management/control	1	3	.77	2.14	
3. Data Base administration	1	3	.77	1.86	
4. Data entry procedures -- general knowledge	1	3	.65	1.57	
A. Access	1	2	.51	1.43	
B. Machine readable documents	1	3	.47	1.93	
C. Off-line manual recording	1	3	.62	2.07	
D. Scheduled on-line manual recording	1	4	.83	2.07	
E. Event driven on-line manual recording	1	4	.83	1.93	
F. Automatic on-line recording	1	4	.86	1.86	
5. Processing modes -- host and timesharing -- general knowledge	1	3	.58	1.79	
A. Card oriented batch	1	4	.73	2.07	
B. Keyboard oriented batch	1	4	.77	2.14	
C. Interactive computing	1	4	.80	1.79	
D. On-line inquiry	1	3	.62	1.93	
E. Data acquisition and control	1	4	.80	1.79	
6. Data transmission -- general knowledge	1	4	.77	2.14	
A. Data conversion	1	4	.76	2.50	
B. Transmission	1	4	.85	2.50	
C. Data control	1	4	.86	1.86	
Shared Rationale: Data control is one of the essential elements of good accounting control. Most essential.					1
Shared Rationale: Understanding data control is very important.					1
7. Processing concepts -- general knowledge	1	4	.85	2.50	
A. Program loading	1	4	.95	2.86	
B. File loading	1	4	.95	2.86	

C. Instruction execution	1	4	1.03	2.86	
D. Program and record fixes	1	4	.99	2.29	
Shared Rationale: The auditor should have a good knowledge of the techniques used for program and record fixes. In many cases these "fixes" are only known to a few highly technical individuals within the organization and no one in the organization supervises these individuals--or--understands what they do.					1
E. Recovery/restart	1	4	.84	2.36	
AREA V: Data Processing Management -- general knowledge	1	4	.80	1.79	
1. Personnel management -- understand and evaluate	2	4	.63	2.36	
A. Staffing	1	4	.74	2.36	
B. Evaluation	1	5	1.14	2.71	
Shared Rationale: It is not that important to know how staff members are evaluated.					4
C. Scheduling	1	4	.91	2.71	
Shared Rationale: Just not important from an audit viewpoint.					4
D. Training	2	4	.74	2.64	
2. Organizational management -- understand and evaluate	1	2	.47	1.29	
A. Data processing organizational structure	1	2	.50	1.36	
B. Relationships with other departments	1	2	.50	1.36	
C. Separation of responsibility	1	2	.43	1.21	
3. Facilities management -- understand and evaluate	1	3	.63	1.64	
Shared Rationale: (also applies to all sub-items) Facilities management is not very popular outside of a few specialized areas--and a general knowledge should be adequate for most auditors. Even when used, what is there to know at the "apply" level?					3
A. Environment	1	3	.61	1.71	
B. Access control	1	3	.65	1.43	
4. DP operations management -- understand and evaluate	1	2	.36	1.86	
A. Systems development/control	1	2	.52	1.50	
B. Programming development, maintenance, and control	1	2	.51	1.43	
C. Job scheduling	1	3	.65	2.50	
D. Charge-back methods	1	5	.96	3.00	
Shared Rationale: It should not make any difference to external					

auditors how the departments are charged for DP use.					4
E. Planning	1	4	.89	2.79	
Shared Rationale: How the DP department plans for future growth in equipment does not concern the external auditor.					4
F. Records management -- retention and control	1	3	.58	2.21	
a. Forms	1	3	.63	2.36	
b. Reports	1	3	.58	2.21	
c. Source documents	1	3	.62	2.07	
5. General knowledge of trends	1	4	.66	2.86	
A. Software	1	4	.74	2.64	
B. Hardware	2	4	.62	3.07	
C. Systems development	2	4	.62	2.93	
D. Applications	2	4	.55	3.00	
E. Programming techniques	2	4	.61	3.29	
6. Evaluation and contracting for	1	4	.91	3.29	
A. Software	1	4	1.03	3.14	
B. Hardware	2	4	.65	3.43	
C. Consultants	3	4	.52	3.50	
7. Implications of	2	4	.58	2.79	
A. In-house versus out-house software development	1	4	.73	2.71	
B. Purchase versus lease/rental	2	4	.70	3.21	
C. In-house versus contract installation management	1	5	1.07	3.07	
Shared Rationale: Not of audit significance.					5
8. Current laws and regulations -- general knowledge	1	4	.73	2.71	
A. Privacy	1	4	.83	2.71	
B. Reporting requirements	1	4	.76	2.57	
C. Trade secrets, patents, and copyright	1	4	.80	3.21	
AREA VI: Specialized Audit Knowledge and Techniques. General knowledge of area.	1	2	.52	1.50	
1. Understand and be able to use	1	3	.61	1.71	
A. Test decks	1	5	1.09	2.50	
Shared Rationale: Antiquated approach.					5
B. Test data generators	1	6	1.36	3.00	
Shared Rationale: (also applies to C and F) Not cost effective for external auditors.					6
C. Tagging and tracing	1	6	1.27	3.29	

Shared Rationale: It is extremely difficult to get audit data for an entire year's operations by using the tagging and tracing technique.					5
D. Integrated test facility	1	4	.91	2.71	
E. Live on-line sampling techniques	1	3	.73	1.71	
F. Logic tracing software packages	2	6	1.02	3.43	
G. Code review and comparison	1	5	1.01	3.36	
a. Application programs	1	5	1.12	3.21	
b. Utility programs	1	5	1.02	3.43	
c. Operating system programs	3	5	.78	4.00	
H. Flowcharting software packages	3	6	.53	3.86	
I. Data/record retrieval using utility programs	1	4	.89	1.79	
J. DBMS data/record retrieval	1	4	.84	2.36	
K. Parallel simulation	1	5	.97	2.79	
L. Generalized audit software	1	2	.50	1.36	
M. Ability to program custom audit software	1	5	1.20	2.29	
Shared Rationale: Very few auditors have the need to program custom audit software. Even when there is a need, it is far better to bring in an experienced programmer.					4
2. Understand computer internal control/vulnerabilities	1	4	.84	1.36	
A. Hardware	1	3	.63	1.64	
B. Software	1	4	.85	1.50	
C. Organizational	1	4	.84	1.36	
D. DP procedures	1	4	.84	1.36	
E. User procedures	1	4	.83	1.29	
F. Systems design, development and implementation	1	4	.85	1.43	
G. Documentation	1	3	.76	1.57	
Shared Rationale: Documentation is not that important to external auditors.					3
H. Forms	1	3	.62	2.07	
I. Data entry	1	3	.65	1.43	

APPENDIX M

EXTERNAL AUDIT RESULTS FROM PHASE III

FINAL PHASE III EXTERNAL AUDIT RESULTS

Area/Item Knowledge Description	Low Value	High Value	Std Dev	Mean	Importance
AREA I: Hardware - Knowledge of equipment in use, their functions and operating concepts	2	3	.50	2.67	
1. Major types of computers -- general knowledge	2	3	.33	2.89	
A. Analog	4	5	.53	4.44	
B. Digital	2	5	1.05	3.11	
2. Major types of digital computers -- general knowledge	2	3	.53	2.44	
A. Micro	3	4	.33	3.11	
B. Mini	2	3	.53	2.44	
C. Conventional	2	3	.53	2.44	
3. Different computer configurations -- general knowledge	2	3	.50	2.33	
A. Stand alone -- no remote I/O	1	3	.60	2.11	
B. Central -- remote on-line I/O	2	3	.44	2.22	
C. Distributed networks	2	3	.44	2.22	
4. Types of operating systems -- general knowledge	2	4	.50	3.00	
A. No operating system -- operator controlled	2	6	1.12	3.33	
B. Sequentially scheduled	3	4	.33	3.11	
C. Multiprogramming	3	4	.44	3.22	
D. Multiprocessing	2	4	.60	3.11	
E. Virtual	3	4	.44	3.22	
F. Emulation	3	5	.78	3.89	
5. Types of storage mediums in use -- general knowledge	3	4	.33	3.11	
A. Primary memory -- core, semiconductor, . . .	3	5	.93	3.89	
B. Secondary memory - tape, disk,	2	4	.60	2.89	
6. I/O and storage devices -- general knowledge	2	3	.33	2.89	
A. Printers	3	4	.50	3.33	

B. Tape drives	2	4	.50	3.00
C. Disk drives	2	4	.50	3.00
D. Mass storage units	2	4	.71	3.33
E. Readers -- card, MICR, OCR, . . .	3	4	.53	3.44
F. Card punches	3	6	1.05	3.89
G. Intelligent terminals	2	3	.53	2.56
H. Microfilm	3	6	.93	4.11
I. CRTs	2	3	.53	2.56
J. Keyboards	3	5	.87	3.67
K. Point-of-sale	3	3	.00	3.00
L. Audio	3	6	.97	4.22
M. Converters	3	5	.67	4.22
7. Communications -- general knowledge	3	4	.44	3.22
A. Modems/data sets	3	5	.71	3.67
B. Line controllers	3	5	.67	4.22
C. Multiplexers/selector channels	3	5	.67	4.22
D. Concentrators	3	5	.67	4.22
E. Types of channels	3	5	.67	4.22
F. Front-end processors	2	5	.83	3.22
G. Cryptographic devices	3	6	1.09	4.22
8. Hardware related code structures -- general knowledge	2	4	.71	3.33
A. Hollerith	2	5	1.01	3.56
B. ASCII codes	2	4	.83	3.22
C. EBCDIC	2	4	.87	3.00
D. BCD	3	5	.78	3.89
E. BAR codes	3	6	.83	4.22
9. Punched card accounting equipment -- general knowledge	3	5	.50	4.00
A. Keypunch	3	5	.50	4.00
B. Verifier	3	5	.50	4.00
C. Sorter	4	5	.33	4.11
D. Interpreter	4	5	.33	4.11
E. Reproducing punch	4	5	.33	4.11
10. Hardware related techniques -- general knowledge	3	5	.60	3.89
A. Parity	3	4	.50	3.67
B. Buffering	3	5	.71	4.00
C. Modularity	3	5	.78	4.11
D. Protocols	3	5	.71	4.00
E. Acknowledgement	3	6	.87	4.33
F. Packet switching	3	6	.87	4.33
11. Specialized systems -- general knowledge	3	4	.44	3.22

A. Data entry	2	4	.60	3.11
B. Word processing	4	6	.97	4.78
12. The operation of components together as a system	2	4	.71	2.67
A. Data transmission	2	4	.71	3.00
B. Data control	1	4	.88	2.56
C. Data manipulation	2	4	.71	2.67
13. Security and control features -- general knowledge	1	3	.73	1.56
AREA II: Software -- general knowledge	2	3	.45	2.21
1. Available languages -- significant features and operating concepts	1	4	.88	2.56
A. High level	1	4	.83	2.22
B. Data base management system	2	4	.73	2.56
C. Specialized inquiry/report generation	2	4	.67	2.78
D. Special purpose	2	4	.67	2.78
E. Modeling/simulation	3	5	.78	4.11
2. Language classifications - significant features and operating concepts	3	5	.67	4.22
A. Machine/PAL/HLL/natural	3	5	.67	4.22
B. Procedural/non-procedural	3	5	.67	4.22
3. Types of programs - general knowledge	2	2	.00	2.00
A. Application	1	2	.53	1.56
B. Utility	1	4	.93	1.89
C. Operating system	2	3	.48	2.63
D. Translator	3	5	.60	3.89
4. Understand and evaluate the software interfaces of	1	3	.60	2.11
A. Application programs	1	3	.50	2.00
B. DBMS	1	3	.67	2.22
C. Distributed systems	1	3	.60	2.11
D. Electronic funds transfer system	1	3	.50	2.00
E. Electronic mail systems	4	6	.84	4.70
5. Understand programming techniques -- top down, modular, structured . . .	3	4	.53	3.56
6. Operation of the major types of DBMS	2	4	.60	3.11

A. Modification of operating system	2	4	.60	3.11
B. Interfaces with existing OS	2	4	.60	3.11
C. Used with back-end processor	3	4	.53	3.56
7. The structure of software -- general knowledge	3	5	.67	3.78
A. System architecture	3	5	.78	3.89
B. Instruction formats	3	5	.71	4.00
C. Program construction	3	5	.78	3.89
D. Translator construction	3	5	.78	4.11
E. Operating system structure	3	5	.71	4.00
8. Software evaluation techniques	2	4	.81	2.94
9. Software trends	3	4	.53	3.56
10. Available packaged software	3	4	.50	3.33
A. Vendors	2	4	.67	3.22
B. User groups	2	4	.71	3.33
AREA III: Systems Analysis and Design -- general knowledge	2	3	.50	2.33
1. Systems development methodologies -- top down, bottom up . . .	2	4	.71	3.00
2. Systems study procedures - general knowledge	2	3	.50	2.33
A. Project origination and approval	2	3	.44	2.22
B. Problem definition/documentation	2	3	.44	2.22
C. Feasibility study	2	4	.67	2.78
D. Systems study	2	3	.53	2.56
E. Systems development	2	3	.50	2.33
F. Systems testing	2	3	.33	2.11
G. Systems implementation methods	2	3	.50	2.33
H. Conversion techniques	2	3	.50	2.33
I. Systems/program maintenance	2	3	.44	2.22
3. Ability to design a simple system	2	4	.71	3.00
A. Batch	2	4	.71	3.00
B. On-line -- few interfaces	2	4	.71	3.00
4. Programming process from authorization to maintenance	1	3	.71	2.00
5. Able to program	3	5	.71	3.32
A. Program assembly language	3	6	.88	4.56
B. High level language	2	5	.83	3.22

C. DBMS language	3	5	.67	3.78
D. Modeling/mathematical language	4	5	.53	4.44
E. At least one language	2	5	1.05	3.11
6. Able to understand and evaluate the design and use of	1	3	.50	2.00
A. Forms and reports	1	3	.60	2.11
B. Multiple organization systems	2	4	.71	2.67
C. Special files -- libraries, indices, tables	1	4	.78	2.89
D. Coding systems	2	5	.83	3.22
E. Multimode processing systems	2	5	.87	3.67
F. Recovery/restart procedures	2	4	.50	3.00
G. Operating systems	3	4	.50	3.33
7. File organizations -- general knowledge	1	4	.88	2.44
A. Sequential	1	4	.88	2.44
B. Index sequential	1	4	.88	2.44
C. Random processing, non-integrated files	1	4	.88	2.44
D. Integrated data base -- batch processing	2	4	.73	2.56
E. Integrated data base -- real-time processing	2	4	.73	2.56
F. Shared files	2	4	.71	2.67
G. Special reports files	2	4	.67	2.78
H. Operating system records/files	2	4	.71	3.33
8. File access techniques -- general knowledge	2	4	.73	2.56
A. Sequential	2	4	.73	2.56
B. Index sequential	2	4	.73	2.56
C. Direct	2	4	.73	2.56
D. Indices	2	4	.73	2.56
9. Diagnostic aids - general knowledge	3	4	.44	3.78
A. Software monitors	2	4	.73	3.44
B. Hardware monitors	3	4	.44	3.78
10. Computer applications -- general knowledge	1	2	.50	1.67
A. Range of applications	1	2	.53	1.56
B. Decision support techniques -- models/simulation	3	5	.73	3.94
C. Specialized applications	2	5	.83	3.22
a. Electronic funds transfer	2	4	.67	2.78
b. Production -- data acquistion	2	5	1.09	3.22
c. Electronic mail	2	6	1.24	4.56

11. Types of documentation -- general knowledge	2	3	.44	2.22
A. Program	2	3	.44	2.22
B. System	1	3	.60	2.11
C. Data processing operations	2	3	.44	2.22
D. User	1	3	.60	2.11
12. General categories of charts -- general knowledge	2	3	.53	2.56
A. Activity	2	4	.71	2.67
B. Layout	1	3	.71	2.33
C. Personal/organizational relationships	1	3	.67	1.78
D. Statistical	2	4	.71	3.33
13. Specific types of charting -- general knowledge	2	3	.50	2.33
A. Program logic	2	4	.87	3.00
B. Hierarchical input, processing, and output	1	3	.93	2.11
C. Systems flowchart	1	3	.60	2.11
D. Process flowcharts	2	4	.71	2.67
E. Gantt	3	6	.87	4.00
14. Solution alternatives -- understand and evaluate	2	4	.60	3.11
A. Types/sizes of computers	2	4	.67	3.22
B. Computer configurations	2	4	.67	3.22
C. Software development -- in-house, contract, . . .	3	5	.73	3.44
D. Special services -- vendor	3	5	.73	3.56
E. Time sharing, purchase, lease .	3	5	.73	3.56
15. Control techniques -- understand and evaluate	1	1	.00	1.00
A. Access to facilities, hardware, software, and data	1	2	.44	1.22
B. Input -- hardware, software, and procedural	1	2	.33	1.11
C. Processing	1	1	.00	1.00
a. Application programs	1	1	.00	1.00
b. Utility programs	1	3	.73	1.44
c. Operating system	1	3	.78	2.11
d. Special applications	1	2	.43	1.76
(1). Time sharing - 3rd party	1	3	.67	2.22
(2). DBMSs	1	4	.87	2.00
(3). Communication networks	1	5	1.12	2.33
(4). Error correction	1	2	.50	1.33

D. Systems analysis, design, and implementation	1	2	.53	1.44
E. Documentation	1	3	.60	1.89
F. Output	1	2	.33	1.11
AREA IV: Data Processing Operations (DP & Departments)	2	3	.33	2.11
1. Tape management/control	1	3	.50	2.00
2. Forms management/control	2	4	.73	2.44
3. Data base administration	2	3	.33	2.11
4. Data entry procedures -- general knowledge	2	3	.33	2.11
A. Access	1	3	.71	1.67
B. Machine readable documents	2	3	.33	2.11
C. Off-line manual recording	2	3	.50	2.33
D. Scheduled on-line manual recording	2	3	.50	2.33
E. Event driven on-line manual recording	2	3	.50	2.33
F. Automatic on-line recording	2	3	.50	2.33
5. Processing modes -- host and timesharing -- general knowledge	2	3	.50	2.33
A. Card oriented batch	2	4	.71	2.33
B. Keyboard oriented batch	2	4	.71	2.33
C. Interactive computing	2	3	.33	2.11
D. On-line inquiry	2	3	.33	2.11
E. Data acquisition and control	2	3	.33	2.11
6. Data transmission -- general knowledge	2	3	.53	2.56
A. Data conversion	2	4	.67	2.78
B. Transmission	2	4	.50	3.00
C. Data control	1	2	.53	1.56
7. Processing concepts -- general knowledge	2	3	.53	2.56
A. Program loading	2	3	.33	2.89
B. File loading	2	3	.33	2.89
C. Instruction execution	3	3	.00	3.00
D. Program and record fixes	1	3	.73	2.56
E. Recovery/restart	2	4	.71	2.67

AREA V: Data Processing Management -- general knowledge	1	3	.60	2.11
1. Personnel management -- understand and evaluate	2	4	.71	3.00
A. Staffing	2	4	.67	2.78
B. Evaluation	2	4	.71	3.00
C. Scheduling	2	4	.78	3.11
D. Training	3	4	.44	3.22
2. Organizational management -- understand and evaluate	1	2	.53	1.44
A. Data processing organizational structure	1	2	.53	1.44
B. Relationships with other departments	1	2	.50	1.33
C. Separation of responsibility	1	2	.44	1.22
3. Facilities management -- understand and evaluate	1	3	.67	2.22
A. Environment	1	3	.67	2.22
B. Access control	1	3	.87	2.00
4. DP operations management -- understand and evaluate	2	2	.00	2.00
A. Systems development/control	1	2	.50	1.67
B. Programming development, maintenance, and control	1	2	.44	1.78
C. Job scheduling	2	3	.53	2.44
D. Charge-back methods	2	5	1.01	3.44
E. Planning	3	4	.44	3.22
F. Records management -- retention and control	1	3	.50	2.00
a. Forms	1	3	.67	2.22
b. Reports	1	3	.50	2.00
c. Source documents	1	3	.50	2.00
5. General knowledge of trends	3	4	.50	3.33
A. Software	2	4	.67	3.22
B. Hardware	3	4	.50	3.33
C. Systems development	2	4	.53	3.44
D. Applications	3	4	.50	3.33
E. Programming techniques	3	4	.53	3.44
6. Evaluation and contracting for	3	4	.55	3.56
A. Software	2	4	.71	3.33
B. Hardware	3	4	.53	3.56

C. Consultants	3	4	.53	3.56
7. Implications of	2	4	.50	3.00
A. In-house versus out-house software development	2	3	.44	2.78
B. Purchase versus lease/rental	3	5	.88	3.56
C. In-house versus contract installation management	2	6	1.27	3.89
8. Current laws and regulations -- general knowledge	2	4	.71	3.00
A. Privacy	2	4	.67	3.22
B. Reporting requirements	1	3	.73	2.56
C. Trade secrets, patents, and copyright	2	4	.71	3.33
AREA VI: Specialized Audit Knowledge and Techniques. General knowledge of area.	1	4	.80	2.07
1. Understand and be able to use	1	2	.43	1.76
A. Test decks	2	5	1.05	2.89
B. Test data generators	3	4	.53	3.56
C. Tagging and tracing	3	5	.71	3.67
D. Integrated test facility	2	4	.67	3.22
E. Live on-line sampling techniques	1	4	.97	2.22
F. Logic tracing software packages	3	4	.50	3.67
G. Code review and comparison	1	5	1.22	3.67
a. Application programs	1	5	1.12	3.33
b. Utility programs	1	5	1.13	3.56
c. Operating system programs	3	5	.78	4.11
H. Flowcharting software packages	4	5	.33	4.11
I. Data/record retrieval using utility programs	1	4	.78	2.11
J. DBMS data/record retrieval	1	4	.88	2.56
K. Parallel simulation	2	5	.87	3.33
L. Generalized audit software	1	2	.50	1.33
M. Ability to program custom audit software	2	4	.78	2.89
2. Understand computer internal control/vulnerabilities	1	2	.53	1.44
A. Hardware	1	3	.60	1.89
B. Software	1	2	.50	1.33
C. Organizational	1	2	.44	1.22
D. DP procedures	1	2	.50	1.33
E. User procedures	1	2	.44	1.22
F. Systems design, development and implementation	1	3	.73	1.44

G. Documentation	1	3	.67	1.78	
H. Forms	1	3	.71	2.00	
I. Data entry	1	3	.71	1.67	

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