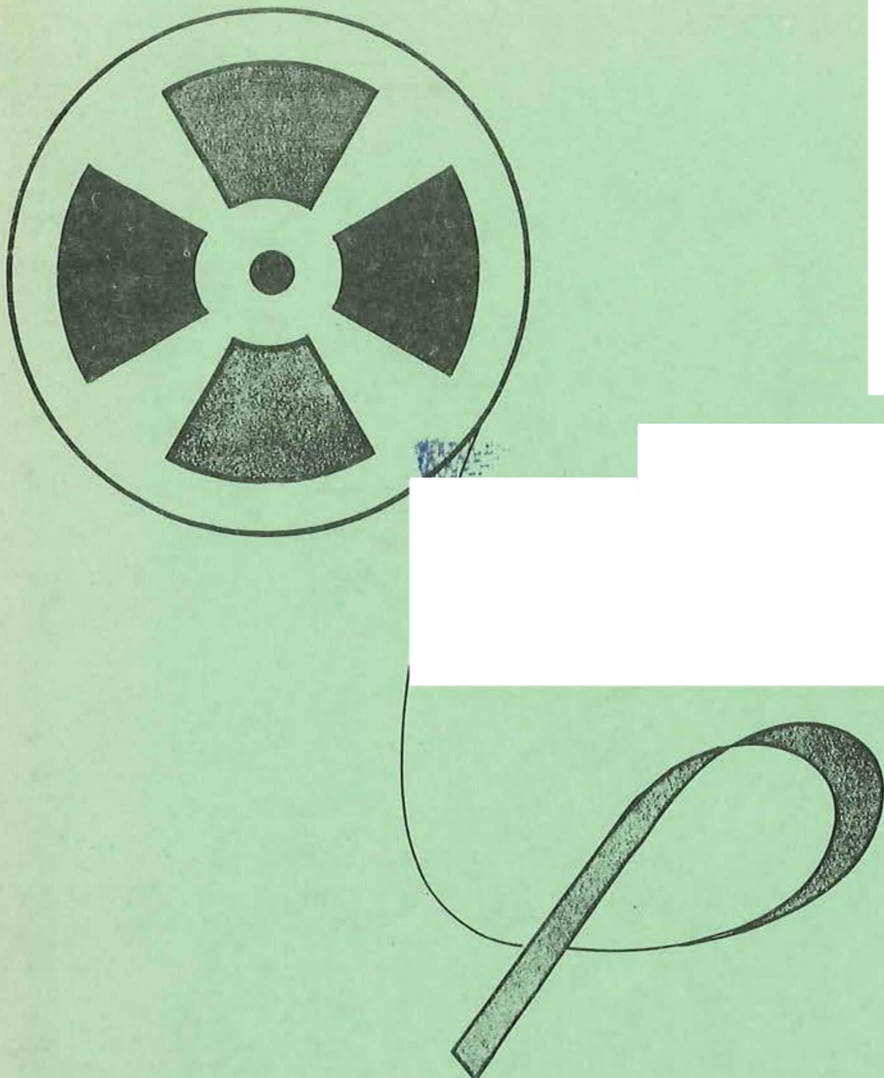

AUDITING A REAL-TIME COMPUTER SYSTEM

A CASE STUDY

UNITED STATES GENERAL ACCOUNTING OFFICE
1973

PREFACE

The GAO Washington regional office reviewed the Automated Hospital Information System (AHIS), a real time data processing system at the Veterans Administration (VA) Hospital in Washington, D.C. Mr. W. C. Grosch was audit manager, Miss G. F. Jasper was on-site supervisory auditor. and Mr. D. L. Myers was staff auditor. During the review, guidelines (see appendix X) were prepared for auditing a real time automatic data processing system to provide a framework for evaluating internal controls and testing their effectiveness and for evaluating the reliability and usefulness of system products.

This case study describes in four chapters how we applied these guidelines in reviewing AHIS. Chapter 1 provides the information necessary for understanding AHIS and its development. Chapter 2 identifies and evaluates the internal controls. Chapter 3 describes the methods used in testing AHIS. Chapter 4 evaluates the use of AHIS products and includes some user reactions and recommendations for improvement.

Only the VA Hospital has AHIS. Other VA automatic data processing capabilities supporting medical and veterans' benefits programs are listed in appendix VIII.

This report supplements an earlier study, "Case Studies of Auditing in a Computer-Based Systems Environment" (B-115369, June 1971).

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CHAPTER 1

UNDERSTANDING THE SYSTEM

For this phase of the audit, we obtained and analyzed the Automated Hospital Information System (AHIS) integrated design summary, design summaries of proposed automated processes for each subsystem, and other pertinent documentation; observed AHIS in operation; interviewed Veterans Administration (VA) personnel; and attended briefings on AHIS design and operation.

OBJECTIVES, SCOPE, AND LIMITATIONS

AHIS objective is to process patient management information to provide maximum assistance to the patient care team. AHIS collects, records, stores, processes, retrieves, summarizes, transmits, and displays patient data where and when needed. The accumulated information is available for medical research, education, and management.

AHIS is oriented to the data requirements and operating procedures of a VA general medical and surgical hospital. It is designed to serve users of patient management data approximately 20 hours a day, 7 days a week, and to interact directly with users on a fast response basis. AHIS maintains pertinent patient admission data, physician's diet orders, radiology and laboratory results, and management statistics and reports.

It is limited to data on admission, diagnosis, treatment, and discharge of inpatients. The design excludes business-type data and information involving textual and analog data.

REAL TIME SYSTEM CHARACTERISTICS

AHIS is classified as real time; that is, it processes data so that the results are available in time to influence the process being monitored or controlled. Data entered through its communication terminals immediately updates all necessary files and produces required notices.

For example, upon request for an X-ray examination, AHIS automatically schedules the appointment after all necessary edits are passed. An appointment slip is generated on the source terminal and the Radiology Service is notified of the scheduled examinations. Both notifications list the day and time of the X-ray. In addition, any hospital service affected by the examination is notified through its own terminal.

AHIS incorporates an interrogation capability whereby information response may be requested at any time and answers are returned immediately. Necessary files are maintained on-line at all times to respond to such requests.

AHIS response time is well within the generally accepted interval for real time processing. All transactions observed require only seconds before initial response is initiated. Response times are somewhat longer during periods of peak use but rarely extend beyond 10 seconds.

AHIS provides for integrating functions and files. Although separate subsystems are identifiable, transactions entered through one subsystem can and do interact with others. This interaction is described in appendixes VI and VII.

AHIS facilitates hospital data collection by establishing data collection points during the period of inpatient care and by monitoring the automated records until all data has been included. AHIS enables the patient care team and hospital management to retrieve patient data and statistics on which to base decisions and evaluations.

AHIS routes communications but this capability is restricted to certain personnel who can enter messages at any terminal for transmittal to one or all hospital terminals.

Certain aspects of AHIS combine both computer and manual processing when human intervention is desired in decision-making. For example, an entry for a radiology order similar to a recently performed examination will cause the system to issue an alert to that effect on the requesting terminal. The operator can override this cautionary edit if the examination is deemed necessary. Thus, both computer and manual processing are combined in one operation.

HISTORY OF AHIS DEVELOPMENT

The initial effort toward AHIS began in 1960 at the VA Los Angeles Hospital Center. A feasibility study was made in 1963, and in 1964 a VA Data Management Advisory Committee recommended installing AHIS at the Washington VA Hospital. The admissions and dispositions (A&D), radiology and dietetics subsystems and a limited laboratory subsystem were installed in 1968 and 1969. Recommendations of a private consulting firm curtailed further development of AHIS in 1972. Appendix II provides a detailed history of AHIS.

AHIS ORGANIZATION

Since early 1965, the pilot project staff and Chief Data Management Director have been responsible for AHIS design and installation. The staff of approximately 30 computer systems analysts and programmers was divided into three teams, each under a systems manager. (See organization chart on page 4).

1. The executive and control team was responsible for operations control and maintenance and development of the AHIS executive processes (see appendix IV).

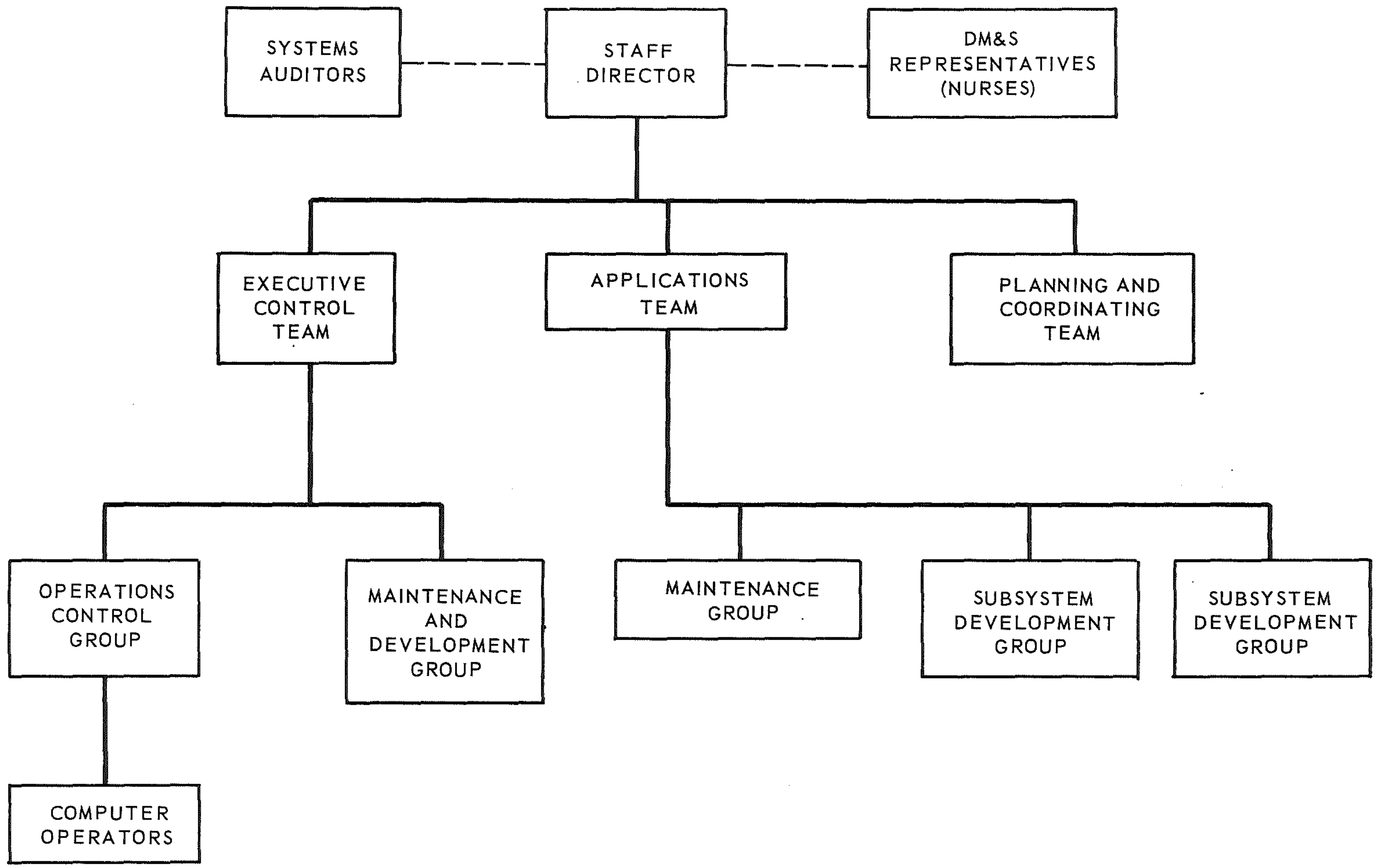
2. The applications team was responsible for changes and improvements to install subsystems.

3. The planning and coordinating team was responsible for varied duties including interacting with hospital personnel to determine requirements and special one-time projects.

Three other groups helped to design, implement, and operate AHIS--nurses, systems auditors, and computer operators. Two experienced VA hospital nurses, representatives of medicine and surgery, were detailed to the project to assist with experimental operations, training, and analysis. An in-house systems audit team was responsible during design and development for certifying the operational status of all AHIS computer programs and modifications. Computer operators, assigned to AHIS by the VA Washington data processing center, were supervised by the executive and control team.

Appendix 1 describes the VA organization.

ORGANIZATION OF THE AHIS PROJECT STAFF



AHIS HARDWARE AND SOFTWARE

Hardware

AHIS uses an IBM system 360 model 40 computer with 262,144 bytes of main memory capacity. The 360/40 is a general-purpose system which can be adapted to a variety of commercial or scientific needs. The standard 360/40 features include an instruction set, a multiplexer channel, and a line frequency time. The AHIS 360/40 also has optional features: decimal arithmetic, floating-point arithmetic, storage protection, and two selector channels.

Peripheral equipment includes a CalComp disk drive and storage control unit and three Ampex magnetic tape drives. The hospital has 46 terminals grouped into 6 different configurations, and 39 of these terminals contain a programed keyboard. Keymats (see p. 14) are used with keyboard to tell the computer the specific type of data being entered.

VA has purchased or will soon purchase most of the AHIS hardware it needs. A more detailed inventory of the hospital's computer equipment is shown in appendix IX, and the AHIS hardware configuration is included as appendix III.

Software

Due to the limited initial capability of the manufacturers' software and the particular needs of the project, overall control of AHIS is maintained by the locally developed AHIS executive programs. These programs provide the automated system control within which AHIS functional subsystems operate. The executive processes provide control over and linkage between the equipment components, IBM library programs, and function-oriented subsystem programs.

Although overall control is maintained by the AHIS executive, the facilities provided in the IBM Basic Operating System (System) are used whenever it is beneficial to AHIS operation. The System consists of several library programs designed to control a 360 computer operation. It includes the assembler, job control, program loader, and utility programs, which are used off-line in developing and cataloging operational programs on the resident disk pack, and the input/output control system and operations supervisor. Except for a report program generator, the system will not support any programing language other than assembly language. The computer programs for the functional subsystems, as well as the executive, are written in assembly language.

Although AHIS real time operations are controlled by an in-house executive in conjunction with the system, a version of the Disk Operating System and a COBOL compiler are available for analysis and testing purposes when AHIS is not in operation.

A description of the executive processes is included as appendix IV.

SYSTEM DESCRIPTION

AHIS is divided into the following subsystems:

	Subsystem	Number of programs
1.	A&D	34
2.	Radiology	18
3.	Laboratory	31
4.	Ward care (partially operational)	2
5.	Dietetic	7
6.	Clinic (partially operational)	2
7.	Patient information	13
8.	Management information	17

As can be seen from this listing, information is functionally structured rather than organizationally, and each subsystem performs a special function in patient care. Original plans included design and installation of medications and surgery subsystems, but these plans have been discontinued.

Although we evaluated internal controls for the entire AHIS, we selected the A&D and radiology subsystems for detailed testing and evaluation of system products. A detailed description of these two subsystems is included as appendix VI.

We made a more limited review of the remaining six functional subsystems, and a brief description of those operations is in appendix VII.

AHIS COSTS

Data management costs to develop AHIS and other systems were not maintained on a project cost basis until fiscal year 1970. Therefore, AHIS costs before 1970 represent the best estimates of assignable costs--$4,899,000--and include no overhead. AHIS costs for fiscal year 1970 totaled approximately $1,140,000, including $844,000 for personal services and travel, $79,000 for data terminal communication, $118,000 for equipment rentals and maintenance, and $99,000 for other expenses. Costs for the first two quarters of fiscal year 1971 totaled approximately $566,000. We did not accumulate any further cost data except for the equipment purchases and monthly charges available at July 1, 1972.

	Purchase price	Monthly contract maintenance cost	Monthly prime shift rental
Central processing unit and peripheral equipment	$522,825	$ 933	$2,074
IBM terminal configurations	160,066	994	3,399
	$682,891	$1,927	$5,473

CHAPTER 2

IDENTIFYING AND EVALUATING INTERNAL CONTROLS

When auditing real time systems, the auditor must rely heavily on internal controls. Consequently, a greater portion of the audit must be directed toward identifying and evaluating these controls. This phase is also important because it allows the auditor to draw tentative conclusions about the system's reliability and to select controls eligible for testing. The results of the tests he performed will confirm or modify his tentative conclusions.

Internal controls in a real time system should (1) safeguard assets, (2) reasonably insure accurate processing, (3) promptly detect errors and irregularities, and (4) provide for proper corrective action.

The following discussion of the internal controls applicable to AHIS is based on (1) documentation review where we evaluated the:

- --Subsystem flow diagrams. In certain instances, we updated these diagrams to identify all input documents, records, files, programs, and output. Representative diagrams are included in appendix V.
- --Copies of planning notes and operating instructions describing computer files and optional segments, specialized routines, and required program documents and standards to provide other AHIS information to the analysts and programers. Complete operating instructions describe the keymats, regular operating procedures, and standby procedures.
- --Narrative descriptions of computer programs and copies of record and file layouts.
- --Samples of source documents, terminal transactions, edits, and reports.

(2) discussions with AHIS personnel and (3) observations of systems operation.

Specific internal questions are included in the guidelines for auditing a real time automatic data processing (ADP) system.

ORGANIZATION AND MANAGEMENT

Independent audit or control group

During the installation of AHIS, systems auditors were responsible for certifying the operational status of all computer programs. They reviewed program documentation and tested each program. When they were satisfied with test results, they added a memorandum of certification to the formal program documentation and the program was ready for installation. The systems auditors were independent of the personnel responsible for installing and operating AHIS. One auditor will remain with AHIS in its current operational status.

We reviewed the certification files and found several instances when changes had been made without auditor certification. The auditors told us that the changes had probably been emergencies and that, should this occur again, they would take steps to insure tighter control over installed programs.

The systems auditors said that in some instances they knew of problems concerning the use of AHIS reports, but their limited authority and scope of work prevented their making improvements. We believe systems auditors' responsibilities could be extended to include evaluating system products, the effectiveness of controls, and the effectiveness of reports, notices, and other input.

Project control techniques

Project control techniques include dividing AHIS into workable subsystems or activities, planning for subsystem development, and using a progress reporting system. AHIS preliminary studies and its division into subsystem are discussed in appendix II and page 6.

AHIS personnel have devised a five-phase development plan for subsystems: (1) definition and design, (2) development of program logic and edits, (3) development of detailed block diagrams, program coding and test data,

(4) testing and audit, and (5) installation. The documentation developed during these phases is available in proposed design summaries, supplemental studies, planning notes, program manuals, and systems auditors' test files and results.

Data management uses a system of project plans and quarterly status reports to inform the VA Administrator of the progress of such projects as AHIS. Detailed weekly progress reports were prepared for the director of data management. Assignments to individual analysts and programers were controlled by a form which stipulated target dates and supplemental reporting requirements.

Separation of duties

The functions and duties of AHIS system designers and programers are separate from computer operation. The AHIS executive and control team personnel instruct and supervise computer operators. Computer operators are rotated periodically, and two or three are on duty in the machine room during all processing.

The data processing files (magnetic tape and disk) are limited in number and are not controlled by a librarian nor are copies of computer programs, although they are stored outside the machine room. Furthermore, computer operators are not restricted from access to terminals capable of originating transaction input. Such lack of control in these areas is generally considered unsatisfactory. However, these conditions did not appear to cause a control problem in this case because AHIS does not process financial data or control assets and the operators are closely supervised.

Personnel

To evaluate staffing, we studied position titles, civil service classifications, qualifications, and experience of AHIS personnel. They were required to meet the Civil Service Commission requirements for series 334 computer systems analysts and programers. Many had been previously assigned to other VA data processing projects.

The staff received on-the-job training through seminars, briefings, and home study programs. The Civil Service Commission, other agencies, and computer manufacturers gave formal training.

Statistics were not maintained for personnel turnover, but, according to AHIS management, turnover did not adversely affect the project. During the curtailment of AHIS development in 1972 and the resultant staff reduction, the personnel remaining were oriented to their new areas of responsibility before experienced personnel were released.

Documentation

We reviewed AHIS system and program documentation and found that it was generally complete and accurate, although not always up to date. System documentation included an integrated design summary of objectives, scope, limits, design considerations, and proposed general system operation. Documentation for each subsystem included a summary of present methods, a proposed design summary, and subsystem process flow charts. We reviewed the summaries for orientation to the system; but more detailed work was necessary, including observation, collection of system products, review of program documentation, and discussion with users to obtain an accurate representation of current system operation. We pointed out to management that the proposed design summaries should be updated to reflect the actual current design of the system.

The documentation for each AHIS program is contained in a loose-leaf program manual and includes a narrative description, logic diagram, record layouts, program listings, auditor certifications, machine requirements, memory use, project assignments (including modifications), and exhibits showing report formats or other information. Test data and results were maintained either in the program manual or in the systems auditors' files.

In some instances program documentation was not current and needed revising. For example, some narrative descriptions that had been revised numerous times with pen and ink needed to be retyped and some logic diagrams needed to be redrawn. Chapter 3 discusses two instances when radiology subsystem programs did not operate as stated in the documentation.

AHIS operators are given detailed operating instructions, including an operating schedule and procedures for (1) placing the system in readiness and starting it, (2) shutting it down, (3) dealing with failures, and (4) restart and recovery.

Program modification and correction procedures

Program modifications are assigned and controlled the same way new programs are, according to AHIS personnel. AHIS supervisory personnel authorize assignments. The systems auditors certify all program modifications in the same way as new programs. Generally, the reasons for change are stated on the form or in an accompanying memorandum. No periodic checks were made to prevent unauthorized program changes from being made, although the systems auditors told us they would take corrective measures if they noted such changes during their work on AHIS.

INPUT CONTROLS

To evaluate input controls, we reviewed (1) the bases for originating real time transactions, (2) the characteristics of the IBM 1050 terminal, (3) the operating instructions for the terminals, including hands-on experience, and (4) the controls used to insure input accuracy and completeness.

Controlled access to terminals

Access to and use of terminals should be controlled to minimize unauthorized or improper use, since such use can cause system problems and unreliable data. At the VA Hospital, terminals are located in administrative work areas, laboratories, nursing stations, and the machine room. No precautions, such as locked rooms or authorized user codes, are taken to prevent unauthorized use. According to AHIS personnel, one control is that correct use of the system requires knowledge of terminal operating procedures. They are aware of the more sophisticated terminals and control techniques available but feel these measures have not been necessary for AHIS thus far. We advised officials that VA should consider using controlled access in any other hospital information systems they might develop.

Visual input verification

AHIS terminals include a programed keyboard which accepts vinyl keymats (see p. 14) printed with field and key designations. Each keymat is designed to serve specific purposes and is coded at the bottom to permit a sensing unit in the keyboard to identify it. After data is keyed in using a keymat, the printer keyboard (typewriter) types a translation for visual verification by the operator. Operating instructions state that the operator, when satisfied that the data is correct, should depress a button which causes the system to accept the data for processing. We observed that operators do not always visually verify the data they have keyed nor always use correction procedures. As a result, we found in examining daily reports and source documents that erroneous social security numbers and patient data were sometimes keyed in the system.

The operator can correct erroneous keyboard input by depressing the correct keys before the data is accepted for processing. For errors in text entries, the operator can backspace up to two characters or cancel the incorrect text and enter it correctly. If the operator is interrupted while using a terminal to enter input data and does not complete the entry within approximately 10 seconds, the transaction will be rejected. The terminal is then available to enter other transactions or to receive messages.

Programed control techniques

Our review of program documentation and observation of processing indicated that AHIS programs include numerous edits or checks to determine the validity and accuracy of input data. If input data violates the program edits, an error message is printed, the transaction is rejected, and the operator must enter a corrected transaction. Programed techniques used include existence, combination, and completeness checks. In certain instances, caution messages are printed for the operator but do not cause the transaction to be rejected.

Existence checks are used to determine whether social security numbers or ADP numbers are active in the system. Examples of error messages associated with these checks are "NO PRIOR CONTACT RECORD ON FILE FOR SSN * * *" and "ADP NUMBER * * * NOT ASSIGNED."

Combination checks are used to check the logical relationship of various portions of the transaction and to

PATIENT IDENTIFICATION				CLINIC/SERVICE/DESTINATION								PATIENT MOVEMENT	MODIFIER	TIME	DAYS
BED 10 9	BED 20 9	BED 30 9	BED 40 9	AGENT CASHIER 9	CT 9	GU 9	NUTRITION	PSYCHOLOGY	VASCULAR TESTING				CLINICAL FOLDER	1600	TODAY ONLY
BED 9 8	BED 19 8	BED 29 8	BED 39 8	ALLERGY CLINIC 8	DENTAL 8	HEMATOLOGY RESEARCH 8	ONCOLOGY	PT	VECTOCARD. LAB				X-RAY FILMS	0800	SUN
BED 8 7	BED 18 7	BED 28 7	BED 38 7	ANTI-COAGULANT 7	DERMATOLOGY 7	HEMODIALYSIS 7	ORTHOPAEDIC	PULMONARY					CLINICAL FOLDER & X-RAY FILMS	0400	MON
BED 7 6	BED 17 6	BED 27 6	BED 37 6	AUDIOLOGY 6	DIABETIC 6	HYPERTENSION 6	OT	RADIATION THERAPY	PATIENT'S WARD			NO ESCORT NEEDED		0200	TUE
BED 6 5	BED 16 5	BED 26 5	BED 36 5	BLOOD BANK 5	ECG 5	MAT 5	PNC CLERK	RADIOISOTOPE				SPECIAL CARE ESCORT		0100	WED
BED 5 4	BED 15 4	BED 25 4	BED 35 4	BRONCHOSCOPY ROOM 4	EEG 4	MED ILLUST. 4	PHARMACY	RENAL				WHEELCHAIR (IV) ESCORT		0030	THU
BED 4 3	BED 14 3	BED 24 3	BED 34 3	CARDIOLOGY 3	ENT 3	MENTAL HYGIENE 3	PM&R	RHEUMATOLOGY				WHEELCHAIR ESCORT		0015	FRI
BED 3 2	BED 13 2	BED 23 2	BED 33 2	CARDIO-PULMONARY 2	ET 2	METABOLIC 2	PODIATRY	SPEECH				STRETCHER (IV) ESCORT			SAT
BED 2 1	BED 12 1	BED 22 1	BED 32 1	CLOTHING ROOM 1	EYE 1	NEUROLOGY 1	PROSTHETIC	SURGERY				STRETCHER ESCORT		IMMEDIATE	CONTINUING SCHED.
BED 1 0	BED 11 0	BED 21 0	BED 31 0	CONTACT 0	GI 0	NEUROSURGERY 0	PSYCHIATRY	TRANSPORTATION		DESTINATION BY TEXT		AMBULATORY ESCORT NEEDED	CANCEL MODIFIER	CANCEL SCHED.	

ORDER NUMBER

KM 863

PATIENT SCHEDULING

502222

check the transaction logically against the status of the files. For example, when an unacceptable reason for a radiology examination is used, the transaction is rejected with the error message, "REASON NOT COMPATIBLE WITH TEST ORDERED." When an entry is made for the disposition of a patient application, admission and other actions must be compatible with patient status or the transaction will be rejected with the message "PATIENT STATUS INCOMPATIBLE WITH TYPE ACTION."

Completeness checks are used to insure that all necessary keys have been pushed. Examples of error messages associated with these edits are "AN ACTION TYPE KEY MUST BE DEPRESSED." and "UNASSIGNED KEY DEPRESSED COLUMN 16."

When a patient is not assigned to the ward entering a radiology order, the following message will be in the order translation but the order will not be rejected: "CAUTION: PATIENT IS NOT ON WARD ENTERING ORDER."

Maintaining a transaction log

All transactions accepted by the system are recorded on magnetic tape along with periodic system status information. In the event of system failure, this information can be used to restart the system. Tape copies of the system status are transferred weekly to a local offsite storage facility.

Automatic checking of terminal transmission

According to IBM documentation, data transmission to and from AHIS terminals is monitored by a parity check. When errors are detected, a message is printed on the computer console log. In addition to parity checking, each terminal is checked for operational status before messages are sent by the central processing unit. If the terminal has been turned off or if a part, such as a printer belt in the terminal is broken, a message will be printed on the computer console log.

We observed AHIS terminals being tested at regular intervals to determine whether they were operating properly. A terminal test subroutine was used to perform tests of programed keyboard input and printer keyboard input and output.

Off-line file scanning

This technique can be used to keep a check on the validity of files or to scan a log of input data. AHIS did not use this technique regularly. We were advised that in 1970 all the names in one computerized file were alphabetized and printed out with their related social security numbers. The printout was then manually analyzed for duplicate names and social security number errors. We recommended to VA that this analysis be performed again to detect errors in the file which had occurred since 1970.

PROCESSING CONTROLS

The objective of processing controls is to insure that programed operations are being performed as intended. Together with reliable input controls, they help to assure the auditor that satisfactory results can be expected from the system. Through discussions with AHIS personnel and review of documentation, we identified three AHIS processing controls--hardware controls, program controls, and controls to prevent unauthorized intervention.

Hardware controls

The IBM 360/40 uses odd parity to monitor the transmission of data and instructions. In addition, the AHIS 360/40 has the storage protection feature which prevents altering of the contents of main storage by storage addressing errors or input from input/output devices.

Computer operators are given detailed instructions on what to do in the event of power, hardware, or program failures. If the failure occurs outside regular working hours and the operators cannot deal with it, designated AHIS personnel are always on call to assist them with recovery.

Regular maintenance agreements exist with the respective equipment manufacturers. All equipment is serviced biweekly between 1 a.m. and 5 a.m. when AHIS is not operating. A member of the AHIS executive and control team informed us that AHIS has had no maintenance difficulties as a result of having equipment supplied by several different manufacturers (see app. IX).

Operating logs are maintained showing hours of use, equipment failures, and unscheduled maintenance calls. If a machine unit fails three or four times in a 2-week period, a report is compiled to justify corrective action by the manufacturer.

Program controls

The program controls AHIS uses include documentation standards, thorough testing and certification procedures for both new programs and modifications, programed edits, program crossfoots, and reconciliations of management report totals.

The contents of AHIS computer program manuals are described on page 11. Other standards have been established for making flowcharts, preparing coding sheets, naming application programs, and labeling magnetic tapes and disks.

AHIS' written standards provide that test plans be developed to include all programs simulating a timespan appropriate for all types of actions. Desk checking of general logic diagrams and program coding precedes test plan implementation. Final testing is planned for most programs in the system and is performed in cooperation with the systems auditors to facilitate their certification of programs and modifications. Most testing uses the card input program (see p. 23.) Occasionally AHIS personnel would operate the terminals to perform on-line tests of a particular system function. Test data and results were generally available for our review.

Installation schedules are coordinated with the hospital administration, and all hospital personnel involved are trained. AHIS personnel assist in the conversion and monitor operations during the conversion period. In some instances, parallel operations are conducted, during which AHIS personnel assist hospital personnel with their increased workloads.

Our review of documentation and observation of processing indicated that AHIS computer programs extensively used programed edits. Examples of AHIS edits are discussed on pages 15 and 16, and our testing of programed edits is discussed in chapter 3.

Program computations monitor the accuracy of management report totals. The totals are accumlated in a real time mode by application programs. Before preparing printed management reports, a computation program crossfoots and reconciles accumulated totals. Crossfoots are used to insure compatability of counter totals derived from application programs, and reconciliations are used to insure compatibility of counter totals derived from application programs with counter totals in the AHIS files. When a crossfoot or reconciliation discloses an out-of-balance condition, a message is printed on the console typewriter and corrective action is taken.

Controls to prevent unauthorized intervention

The complex AHIS executive and the close supervision of operations personnel tend to prevent any unauthorized intervention in AHIS operations. However, as an additional precaution, all operator-initiated communications to the system are recorded on the console typewriter log. This log is reviewed daily by AHIS supervisory personnel to monitor operator performance and operating conditions requiring additional instructions or machine maintenance.

OUTPUT CONTROLS

The objectives of AHIS input controls are to insure that hospital personnel receive appropriate reports promptly. All reports except user initiated requests through the patient information subsystem are printed by the system according to a preestablished schedule. Printing reports according to a system schedule provides positive control over their production and insures that reports directed to specific terminals are received at the appropriate locations. For reports printed in the computer room, the operators are given detailed printer setup and report distribution instructions. The operators also review the reports for reasonableness before distribution.

Persons responsible for input transactions often control reports and other output received at the terminals. This violates the principle of separation of functions but in this case does not represent a significant weakness in internal control because AHIS does not process financial data. However, after evaluating the use of system products (see ch. 4), we suggested certain admissions and dispositions subsystem reports to be subject to more thorough management review.

In certain instances, the types of data that can be received at selected terminals is restricted. For example, diet cards cannot be requested from terminals in the admissions area.

SECURITY OR DISASTER CONTROLS

The efficient operation of numerous VA hospital activities depends upon reliable operation of AHIS approximately 20 hours a day, 7 days a week. Therefore, in addition to the controls previously discussed, AHIS personnel have taken further measures to protect against complete loss of files and to provide for alternatives in the event of prolonged hardware failure, including physical security, periodic checkpoints, offsite storage, and standby procedures. Currently, there are no provisions for using alternate or backup facilities.

The AHIS computer room is in a remote wing of the hospital and is generally not accessible to hospital personnel, patients, or visitors because it can only be entered by passing through offices occupied by AHIS personnel. Doors leading to the AHIS area are locked except during the administrative workday and are opened only to announced visitors. Supervised tours of the computer room are conducted occasionally.

At regularly scheduled intervals, the executive subsystem initiates an automatic checkpoint which records on magnetic tape the status of core storage and the disk storage data files. In the event of a failure, the copied records can be restored to core and disk to reestablish the system. The transactions recorded on the transaction log (see p. 15) are then automatically reprocessed to bring the status of the system up to the current time. Automatic checkpoints are taken at approximately 3-hour intervals throughout the day and the operator can initiate additional checkpoints through the console.

Local offsite storage is used for tapes, disks, and punchcards containing data or programs considered vital to AHIS continuous operation. The records stored in this matter are (1) magnetic tape copies of the AHIS disk packs (weekly), (2) program source cards (whenever a program is certified or a tape has been in storage for 6 months), (3) inactive tape files (weekly), and (4) program control card decks (whenever changed or replaced).

Standby procedures are provided for handling data when the system is not functioning. These procedures are included in the AHIS operating instructions and are specifically tailored to each hospital function using the system.

Currently, AHIS has no provisions to use alternate or backup facilities in the event of prolonged hardware failure. AHIS personnel had requested that a backup 360/40 be provided to support AHIS development, testing, and operation. However, in accordance with the recommendations of a private consulting firm, VA has not provided the backup computer. Although backup would be desirable, in view of AHIS standby procedures, discontinuance of medications and surgery subsystems, and expenses required to duplicate some or all hardware components, we believe the decision to provide backup can be postponed until the plan for ADP systems is completed (see app. II).

CONCLUSION

Our identification and evaluation of internal controls indicated that AHIS controls were adequate for testing the operation of the system and for providing that it operates as intended.

CHAPTER 3

TESTING THE SYSTEM

To determine whether AHIS was operating as intended, we monitored selected operations, prepared and used test decks, and performed on-line testing.

MONITORING

Monitoring is a review of all input and output during a defined period. We used this technique to evaluate admissions and dispositions and radiology subsystems' procedures and controls and to assist in evaluating the use of subsystem products (see ch. 4).

For the admissions and dispositions subsystem we collected carbon copies of transactions, messages, and reports for 3 consecutive days from two admissions area terminals and two ward terminals. Reviewing this material allowed us to trace AHIS transactions and messages for selected applicants from the time they were identified to the system until they were admitted to a ward.

For the radiology subsystem, we collected carbon copies of transactions, messages, and reports for 2 consecutive days from the X-ray reception terminal. Using this material we were able to observe the transaction flow for scheduling X-rays, preparing worksheets, transmitting results to the wards, and preparing final reports.

Although monitoring was quite useful for identifying system procedures, edits, and other controls, we concluded that monitoring alone was not a sufficient test because we only obtained copies of transactions, controls, and reports that occurred during the monitoring period. Therefore, we supplemented the monitoring technique with test decks and on-line testing.

TEST DECKS

A test deck is a set of artificial transactions designed to test the controls and procedures in a computer program and we used this technique to test the program controls and processing of the radiology subsystem.

Since we wanted to test a volume of transactions without using the actual terminals for input and output, we wanted to use a program which simulated terminal input and output. The AHIS program which performs this function is the card input program. It enables transactions that would normally be entered from the remote terminals to be entered from the card reader. In addition, terminal output can be rerouted to the high-speed printer.

We developed radiology test deck transactions by reviewing and analyzing subsystem documentation and AHIS operating instructions which indicated subsystem objectives, edits, and operating procedures. We also used selected transactions from the test decks used by AHIS programers.

We included each known type of valid and erroneous transaction in our tests and prepared worksheets showing all transaction layouts and results that should occur as a result of processing the tests. AHIS personnel reviewed the transaction layouts to verify the validity of each action. The transactions were then keypunched into cards and each card was verified with the worksheet for keypunching accuracy.

We divided the test transactions into several separate decks to facilitate computer processing and manual review of functional test areas. In case of a system failure, punch-card problems, or inadequate test time, not all the test transactions would have to be rerun. Tests of the following functions were prepared.

--Basic radiology orders and edit checks.

--Cancellation and rescheduling actions.

--Controls to prevent entries from unauthorized terminals.

--Radiology reception actions in scheduling appointments.

--Radiology result entries and edit checks.

The computer processing of the test decks was performed during normally scheduled third-shift test time and was observed by a GAO representative. The test decks were processed with actual programs used during normal AHIS operation. However, the master file used consisted of dummy patient data specially constructed by AHIS personnel for testing operations.

The output from processing the test decks was then reviewed to determine whether actual test results were compatible with expected results and two areas of discrepancy were noted.

1. The test results indicated that regular, nonemergency radiology examinations were being scheduled on holidays and weekends. According to program documentation, only emergency examinations should be scheduled during these periods. Discussions with AHIS programers revealed that the documentation was erroneous and that our test results were correct. We talked with radiology personnel who expressed discontent with weekend and holiday scheduling, and would like the system to accept nonemergency examinations on weekends and holidays but schedule them on a "perform when available" basis instead of assigning a specific time. We suggested that radiology personnel communicate their request to AHIS so that the appropriate programing changes could be made.

2. AHIS radiology subsystems documentation states that a particular type of examination ordered after 6 p.m. and requested for that night will be scheduled at current time plus 30 minutes. Our test results showed the examinations were being scheduled on an immediate basis. Programing personnel stated that the scheduling had been changed to the immediate basis but the documentation had not been updated. Radiology personnel agreed that scheduling should be on an immediate basis.

Processing of the test decks verified the existence and effectiveness of program controls and the operation of programs as intended. Detailed knowledge of the system was required to design and use the test decks. The cooperation of AHIS personnel and the availability of good program documentation helped to provide us this detailed knowledge. We believe using test decks is a workable alternative for testing real time systems.

Major disadvantages in using test decks for evaluating real time programs are (1) terminal operation is not being tested and (2) programs are not being tested in the actual real time environment, where random demands are being made upon the system. To compensate for these disadvantages, we devised additional transactions for on-line testing.

ON-LINE TESTING

The most effective method for testing programed procedures and controls in a real time system is to devise test transactions and enter them from a terminal during live system operation. However, only transactions can be used which will not alter the data base or otherwise disrupt the system's operation. To develop on-line tests, documentation and procedures are reviewed and analyzed in the same manner as for test decks. However, the auditor is limited to testing only those transactions designed to violate known system edits and will be rejected.

We selected several test transactions from our radiology test decks which were designed to violate known edits. AHIS personnel processed the tests for us during live system operation by establishing the identity of an actual hospital patient and entering the transactions at a terminal. All the test transactions were rejected.

Another form of on-line testing we used was to make on-line inquiries using the information inquiry capability provided by the patient information subsystem. We used this capability to obtain information on patient status, administive data, and prior contacts with the hospital.

Use of on-line testing verifies the existence and effectiveness of program input controls but does not allow the auditor to test the operation of normal processing procedures. We found the same level of detailed knowledge was required for on-line testing as for test decks. We believe that on-line testing should be used in real time system audits but should be supplemented with other methods.

CONCLUSION

Our testing of the system disclosed only two areas of discrepancy as previously discussed. Testing confirmed our preliminary judgment that AHIS was adequately controlled and was operating as intended.

CHAPTER 4

EVALUATING USE OF SYSTEM PRODUCTS

During the work described in the preceding chapters, we made a preliminary judgment on how well AHIS was fulfilling its objectives. For those subsystems evaluated, it appeared that AHIS was processing patient management information to provide meaningful assistance to the patient.

To substantiate our preliminary judgment and to determine whether potential benefits (see app. VI) were being realized, we (1) evaluated the use of specific system products, (2) investigated the use made of each product and discussed the value of each at the user level, and (3) obtained user reactions to the system, and where possible, suggestions for improvement. Generally, system products were being used as intended. The following paragraphs discuss two reports for which we recommended more effective use. Also discussed are some user reactions, recommendations for improvement, and our overall conclusions.

TWO REPORTS REQUIRING MORE EFFECTIVE USE

Application pending-for-admission report

As described in appendix VI, entering applicant's name and social security number into AHIS creates an automated record showing his status as application pending. The applicant remains in this status until a disposition transaction, such as an admission or cancellation, is entered. On the day of application, the automated record is reviewed every 2 hours and a message is printed on a terminal in the admissions area if the application is still pending. A similar notice is also produced each morning for applications from previous days which lack disposition entries.

During our monitoring of admissions and dispositions terminal activities, we observed that the application-pending-for-admission reports appeared to be excessively long and contained names of applicants who had applied weeks earlier. Many of the applicants on the list had withdrawn their applications and hospital personnel were not taking the time to follow up on the list. From later observation and discussion with hospital personnel, we concluded that both the

2-hour report and the daily report were not being used to their maximum advantage. We recommended that more effective use be made of the applications-pending report to insure processing applications without undue delay.

Incomplete application list

In certain instances, hospital personnel were unable to immediately complete all data items on applications for patients admitted for care. Such applications are designated to AHIS as being incomplete and it prints a daily list of incomplete applications so that personnel may take steps to complete them. This list was not being used because personnel did not realize the importance of completing application forms. We recommended that the list be used more effectively.

USER REACTIONS AND RECOMMENDATIONS

The chief of the medical administration division informed us that both he and his employees had accepted AHIS. He was favorably impressed by the decreased manual workloads required for report preparation and other administrative functions. He would like the medications subsystem implemented for additional benefits.

The chief, dietetic service, stated that AHIS was of great benefit in providing timely information on patient movement and diet orders. Before AHIS, about 70 percent of the patients' food trays were prepared without adequate information as to patient location, diet status, and diet content. She is quite interested in seeing AHIS capabilities expanded, especially an interface of diet ordering with drug and laboratory ordering.

Radiology service personnel identified several specific problems associated with the radiology subsystem's operation. The chief technician stated that AHIS reduced the time required to request radiology examinations and report results. However, he was dissatisfied with examination scheduling on weekends (see p. 24) and the timing of daily radiology schedules. We recommended that he communicate this to AHIS personnel.

CONCLUSION

Our evaluation confirmed our preliminary judgment that AHIS is well received by hospital personnel and contributes to efficient hospital operation. We determined that potential benefits are being realized (see app. VI). In several instances, however, we recommended that reports be used more effectively. In some instances, hospital personnel apparently had not adequately communicated their needs for the system to AHIS personnel. We brought this to the attention of hospital and AHIS officials who said they would consider establishing formal communication procedures.

Our review of the effectiveness of the AHIS system was limited in scope for several reasons--the study and recommendations made by a private consulting firm (see p. 33), the formation of a VA task force for evaluating AHIS and all VA computer systems, the curtailment of further AHIS development until the task force completed its work, and the fact that AHIS is a pilot program still in the development stage. For a more complete evaluation of the system, the computerized operations of AHIS should be compared to the manual operations of a similar size VA hospital which does not have an automated information system and to other Government and commercial hospitals which have automated systems.

We believe that such an evaluation should be made before AHIS or a similar system is implemented throughout VA.

ORGANIZATION OF VA AND WASHINGTON VA HOSPITAL

VA is responsible to the President for administering veterans' services and benefits and the laws which govern them. VA programs are directed by the Administrator of Veterans Affairs through three major departments.

- --The Department of Medicine and Surgery is responsible for medical and related benefits including the operation of VA outpatient clinics, hospitals, domiciliaries, nursing homes, and restoration centers.

- --The Department of Veterans Benefits is responsible for compensation, pension, loan, vocational rehabilitation, and insurance operations.

- --The Department of Data Management integrates all VA processing functions.

It has made systems studies, designed, developed, and installed new ADP systems, furnished technical advice and assistance to all VA organizations, and provided assistance on communications.

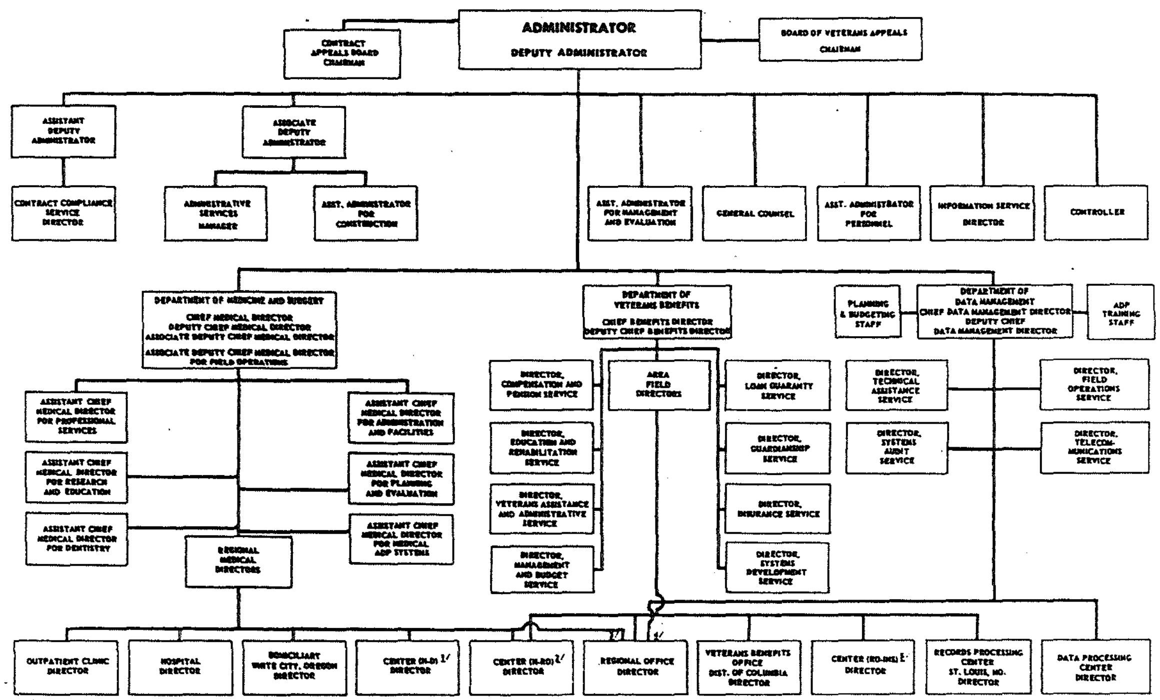
An organization chart is on page 31.

The Washington VA Hospital is one of 168 VA hospitals. It is a teaching hospital affiliated with the medical schools at the George Washington, Georgetown, and Howard Universities and has 708 operating beds in 22 nursing units, as shown in the table below.

Medical service	Bed capacity	Nursing Units
Medical	265	7
Medical (intensive care units)	8	1
Surgical	191	5
Surgical (intensive care units)	10	1
Neurological	54	2
Psychiatric	180	6
Total	708	22

The hospital employs two assistants to the director, an assistant director in charge of directing and coordinating hospital administrative activities, and a chief of staff responsible for patient care, research, and educational activities. AHIS primarily serves functions under the chief of staff. However, the assistant director also relies on AHIS to assist with administrative functions for examination, admission, treatment, transfer, and disposition of beneficiaries.

ORGANIZATION OF THE VETERANS ADMINISTRATION



1/ Combined Hospital and Domiciliary.
2/ Combined Hospital and Regional Office.
3/ Outpatient Clinic where authorized.
4/ Data Processing Center when authorized.
5/ Combined Regional Office and Insurance Center.

(Revised November 7, 1972)

HISTORY OF AHIS DEVELOPMENT

This AHIS concept began in 1960 when a local research contract was established between the VA Los Angeles Center and the System Development Corporation (SDC), Santa Monica, California, to formulate a system description of general medical and surgical hospital activities. In January 1961, medicine and surgery contracted with SDC research and development in patient care and medical research. One specific objective was the application of ADP techniques to relieve physicians and other medical personnel of the time-consuming task of collecting, recording, storing, and retrieving patient data. After the Data Management Department was organized in February 1963, it became responsible for administering the initial and supplemental SDC contracts.

In 1963 VA and SDC made a feasibility study at the Wadsworth VA Hospital in California. The study included approximately 50 major functional areas of the hospital and led to developing a conceptual AHIS design.

A VA data management advisory committee in June 1964 recommended research, including program testing and experimentation toward an AHIS system; and the pilot AHIS project was established at the Washington VA Hospital in early 1965. When initial design of the system was undertaken, the development of the executive and the A&D subsystems was emphasized.

In 1966, the committee recommended installing a limited but fully operational portion of AHIS at the Washington VA Hospital, and in June 1968 the A&D subsystem was installed. At the same time, planning and design on other subsystems continued. Both the radiology and dietetics subsystems were installed in March 1969, and initial elements of a limited laboratory subsystem in late 1969. Portions of patient and management information subsystems were installed concurrently.

Other design studies

Part of the AHIS design effort included a time-oriented study of doctors' orders for the various types of wards and study of nursing use. A study was also made to identify specific data items required for both the previous manual system and the proposed automated system. This documentation was retained as a reference for further AHIS design and alterations.

Equipment studies

The IBM programable matrix keyboard (IBM 1092) was selected as the input device for the AHIS project, but other terminal devices were studied to determine their potential future value.

In 1967 the competitive market was surveyed for suitable AHIS input/output devices. A total of 77 manufacturers were contacted and discussions were held with or demonstrations were conducted by those selected firms responding favorably. VA then prepared a summary of available equipment, including specifications and advantages of each. Analysis of these factors indicated that five input/output devices had future potential.

AHIS was tested on various equipment. One test evaluated the IBM 1052 printer keyboard and 1092 programed keyboard in a parallel mode with an IBM optical image terminal to determine advantages and operator reactions to each. Findings were summarized, listing the advantages and disadvantages of each configuration. A similar format was followed for other types of equipment tested.

Study of data processing within VA

Between May and October 1971, a private consulting firm, Technology Management Incorporated (TMI), investigated the efficiency and effectiveness of VA's data processing, including the AHIS project in Washington. In its October 1971 report, TMI recommended that VA users of data processing assume greater responsibility for ADP research and system development and that VA formulate a master plan for ADP medical applications. TMI recommended that VA not continue developing AHIS, believing that AHIS proved that a patient-care-oriented, automated hospital information system was feasible, but that the benefit received did not warrant incurring further costs.

In response to the TMI study, VA established two task groups--one to plan for developing, implementing, and operating ADP systems to support all facets of the VA medical care program and one to study the reorganization of data processing functions. The work of the first group will include a study of AHIS and other ADP medical systems to determine how they can contribute to the VA medical care program. Until the

ADP plans are completed, AHIS development will be curtailed, leaving in operation only those portions of the system that have been designed and installed.

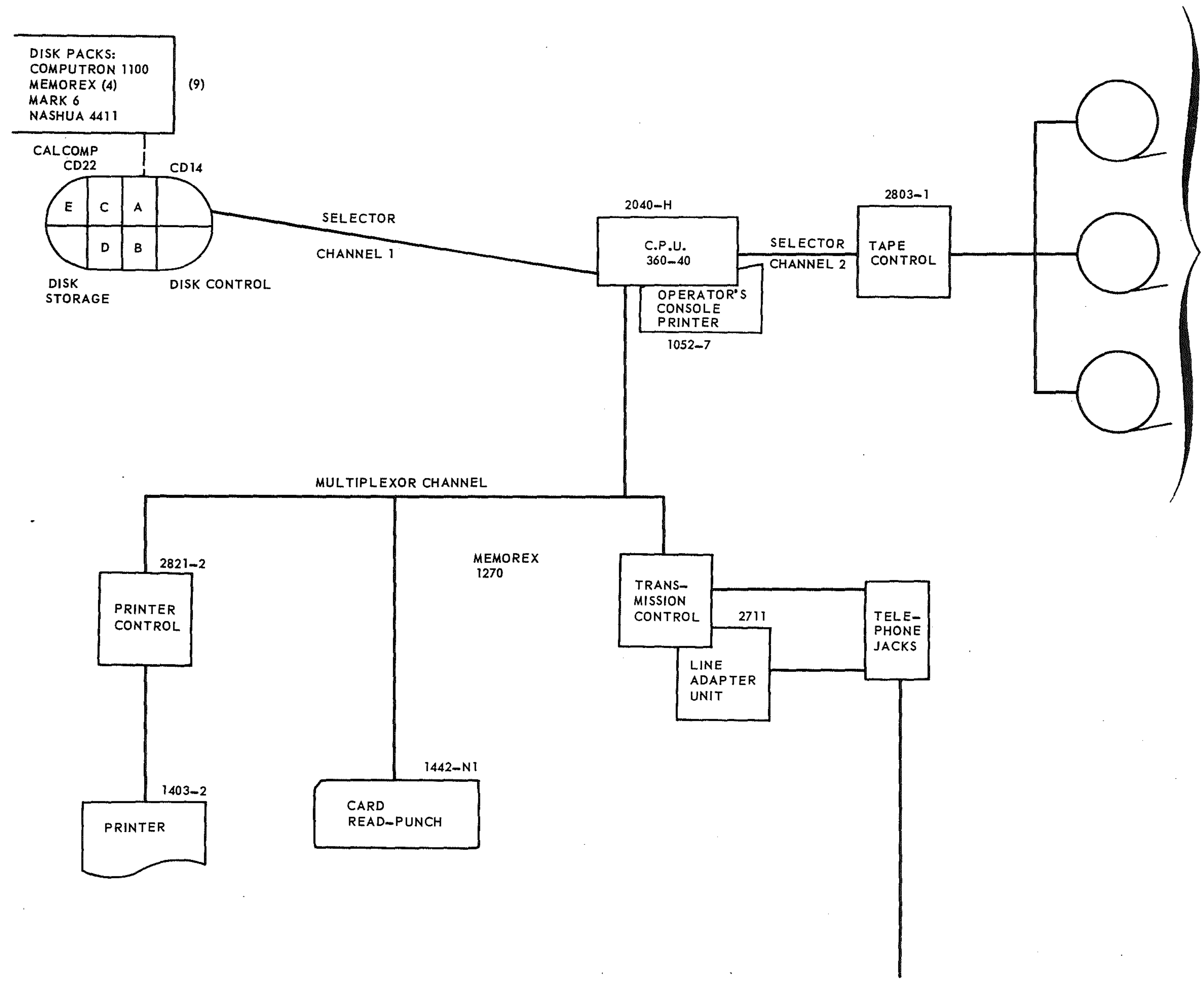
In response to the TMI study, some reorganization has taken place. The systems requirement and design function for medical ADP systems has been transferred from data management to medicine and surgery under the assistant chief medical director for ADP systems who supervises

1. professional requirements and design service,
2. medical systems management service,
3. Administrative and management system service.

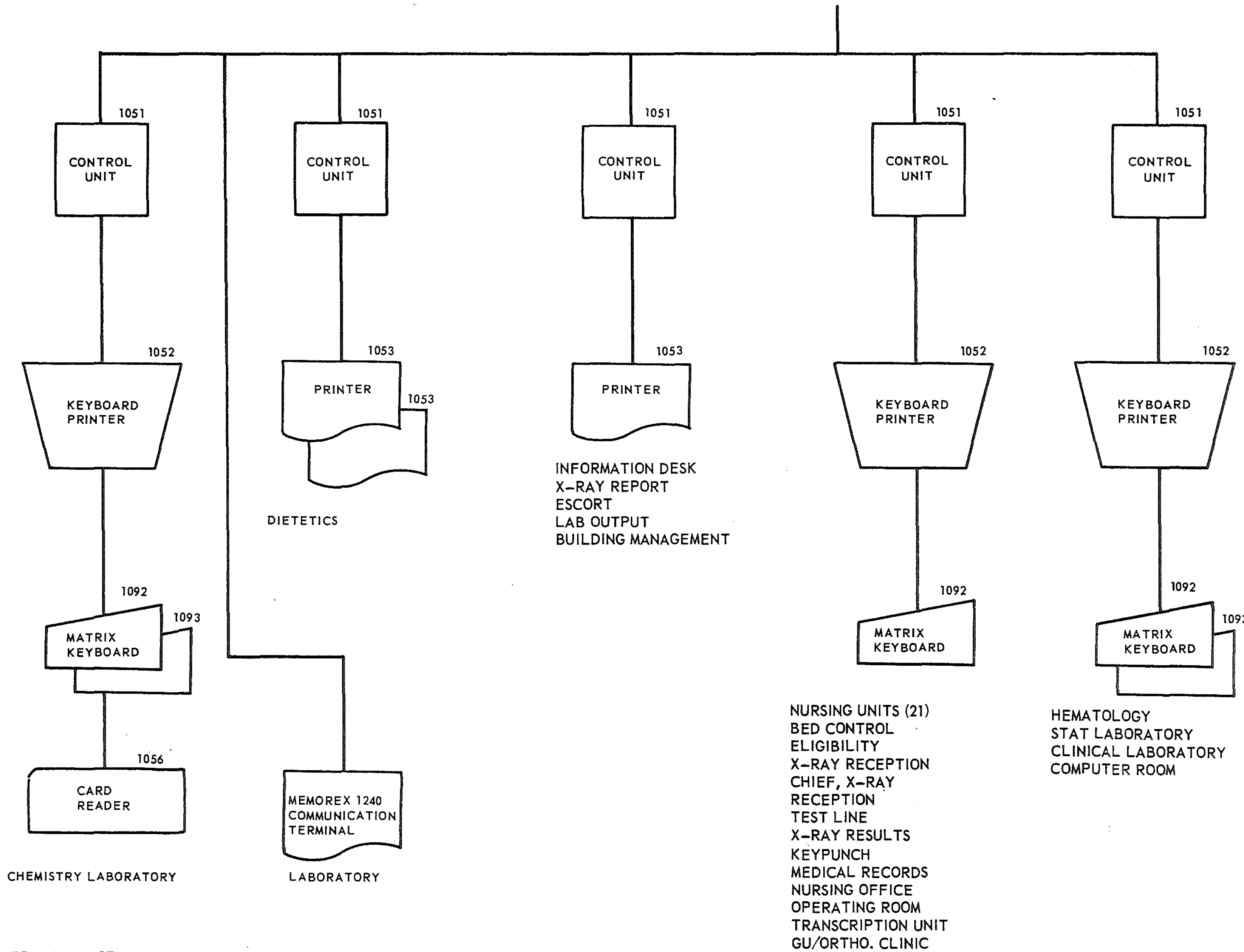
The AHIS project at the Washington VA Hospital was officially transferred in July 1972 to the office of the director, data processing center, Washington. Under this organization the AHIS project has been redesignated as the AHIS Systems Division and classified as an operational system rather than a research and design project. The AHIS project staff, numbering 32 in March 1972, was reduced to 11 by early July 1972. The remaining staff will be responsible for maintaining AHIS in operational status.

APPENDIX III

AHIS HARDWARE CONFIGURATION



APPENDIX III



NOTE: MANUFACTURER IS IBM UNLESS OTHERWISE SPECIFIED

APPENDIX IV

DESCRIPTION OF EXECUTIVE PROCESSES

The AHIS executive process consists of a series of processes which control and link the equipment components, the IBM basic operating system, and the function-oriented subsystem programs. Appendix III shows the AHIS hardware configuration. The IBM library programs and the function-oriented subsystems are listed on pages 5 and 6.

AHIS executive process design provides for subdividing the central processing unit core storage into fixed and dynamic storage areas. Portions of the AHIS executive, the IBM basic operating system, input areas, operating controls, and certain tables are resident in the fixed area at all times. Various other tables, indexes, and transient data records use the dynamic storage areas, as required.

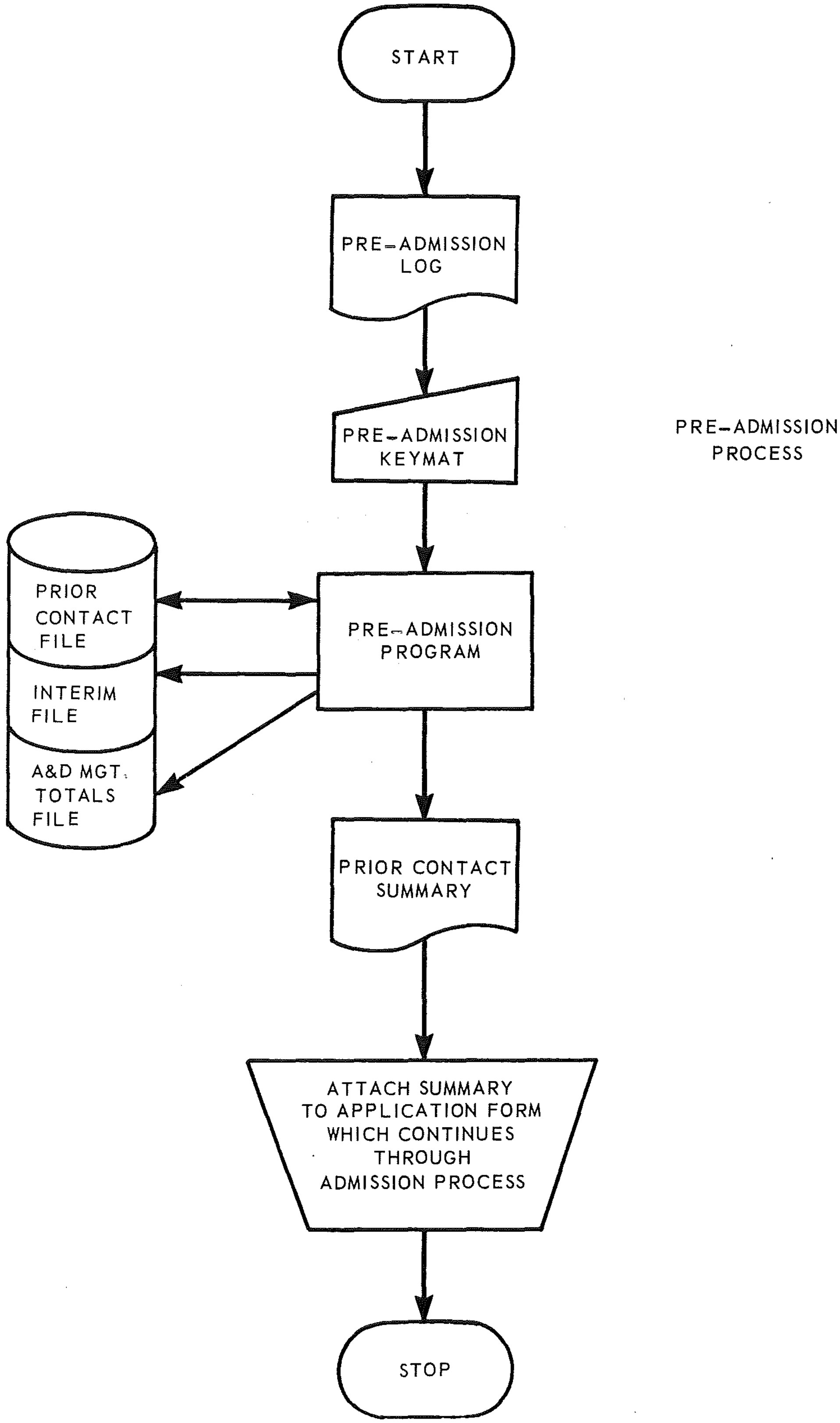
The active program areas are allocated to one of two fixed work areas, which are used, as required, to store the transaction being processed, its related records or data, and the problem program. When processing is completed, the necessary data is transferred to dynamic storage or recorded on the random storage devices. The work area is then available for the next transaction. The problem program areas are used alternately so that when processing one transaction, the alternate area may be used for program input and for data required for the next transaction.

The executive initiates polling (an inquiry to each remote terminal to determine a need for service) and the transaction to read into the computer when a positive response is received. The transaction is placed in the input queue, selected for processing, assigned a problem program area, and designated as the transaction controlling the originating station and its communication line. The transaction is analyzed to determine its processing program, data, and record requirements. When all data and programs have been retrieved from the random storage devices, the problem program begins processing. As output is generated, the executive subsystem controls the dispatch actions and the communications line to insure output continuity. When all actions required for a transaction have been completed, control of the line is relinquished.

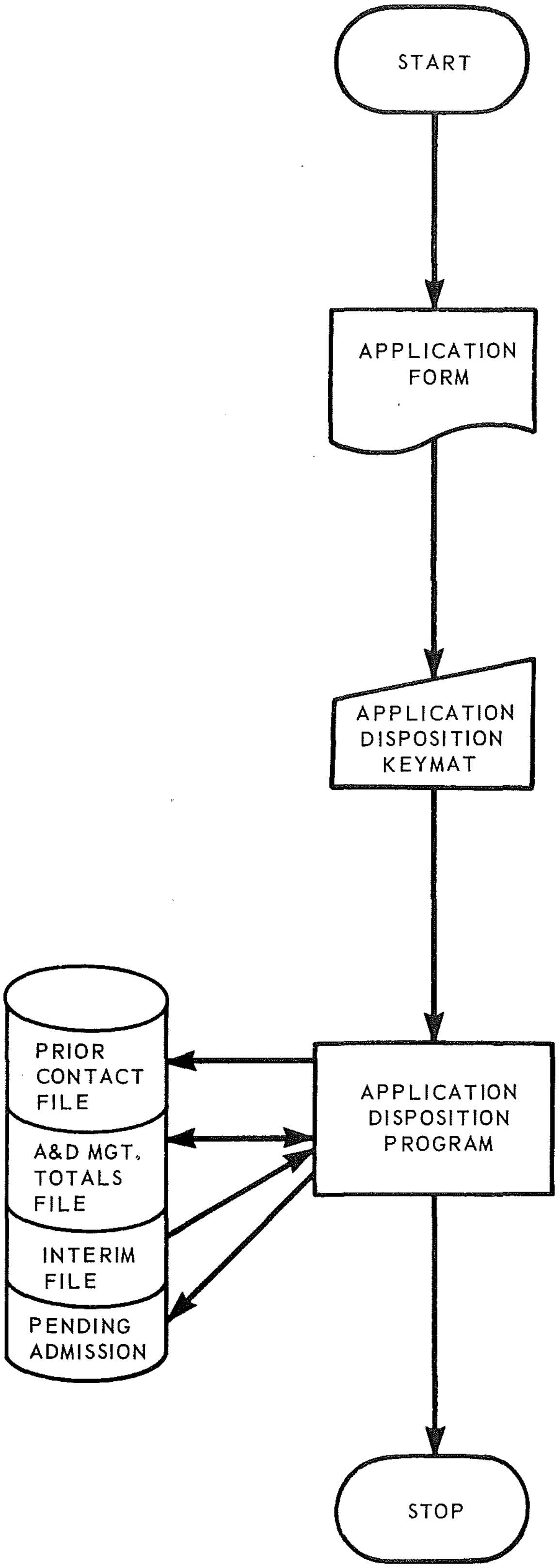
At 10-minute intervals the executive scans a series of tables to determine the need for time-oriented, system-initiated actions, such as reports, worksheets, and follow-up actions. The scans determine which programs should be executed to fulfill the required actions. One of the two problem program areas is used for processing the batch programs. Alternate processing of batch and remote transactions occurs to prevent delays of remote processing while the batch processes are active.

As transactions are completed they are recorded on magnetic tape with periodic system status information (checkpoint). If systems or equipment malfunction, restart of the system is made from the most recent valid checkpoint.

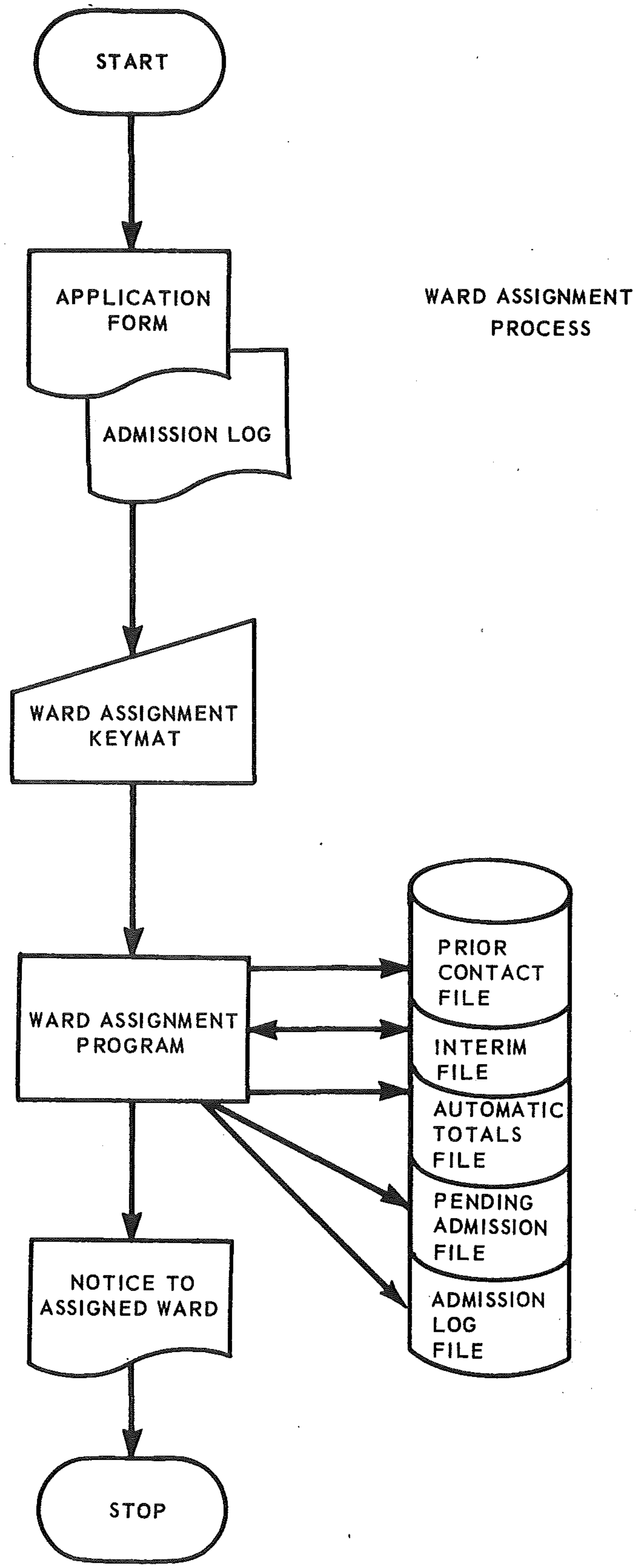
ADMISSIONS AND DISPOSITIONS SUBSYSTEM FLOWCHART SAMPLES



APPLICATION DISPOSITION PROCESS



APPENDIX V


START
APPLICATION FORM
ADMISSION LOG
WARD ASSIGNMENT PROCESS
WARD ASSIGNMENT KEYMAT
WARD ASSIGNMENT PROGRAM
PRIOR CONTACT FILE
INTERIM FILE
AUTOMATIC TOTALS FILE
PENDING ADMISSION FILE
ADMISSION LOG FILE
NOTICE TO ASSIGNED WARD
STOP

DESCRIPTION OF A&D AND RADIOLOGY SUBSYSTEMS

A&D SUBSYSTEM

The A&D subsystem is made up of several information processes the hospital requires for screening applicants and determining their medical needs, legal eligibility for care, admissions or rejections for such care, and subsequent dispositions. The subsystem also serves the related functions of intrahospital transfers; patient leave and pass status; bed control; and management reporting of patient activities, census, and cumulative statistics.

Processing

The hospital receptionist performs the first step in the admission process by entering the applicant's social security number into the system and the applicant's name if he has had no prior contact with the Washington VA Hospital. AHIS establishes a record for each applicant in the interim file and automatically assigns an ADP identification number to identify the applicant during his current contact with the hospital.

The applicant then undergoes medical examination and administrative screening to determine his need for care and legal eligibility and is (1) determined not to be in need of care, (2) placed on the waiting list, (3) scheduled for later admission, or (4) admitted to a hospital bed. When the application disposition is keyed into AHIS, it is edited and translated for operator verification. Upon verification, both prior contact and interim files are updated.

Throughout this administrative process, AHIS monitors the application's status and automatically generates a followup notice in the admissions office every 2 hours if the disposition has not been entered. AHIS produces similar notices each morning for previous days' applications which lack disposition entries.

Once the applicant is admitted for care, AHIS continues to maintain his status and location information. When the applicant is admitted as a bed occupant, indicative information is entered at admissions establishing the patient's master record in the master record file. A ward assignment entry is also made at this time, automatically generating an admission notice on the assigned ward's terminal. The ward enters a bed assignment and updates the patient's record, bed census, and management data files and produces appropriate notices at the information desk and admissions office.

AHIS also enters and monitors any change in location or status, including intraward transfers, pass and leave actions, and patient discharges. Again, appropriate notices are produced at locations the action affects and patient files are updated. Followup notices are generated when necessary actions have not been entered in accordance with an original transaction entry.

A&D processing interrelates with both the radiology and the dietetic subsystems. During the preadmission physical examination, the attending physician may request that a patient have an X-ray to determine whether hospital care is required. In this case, the radiology order is placed from the admissions office terminal and the application remains in a pending status until the test results are received. The dietetic subsystem is affected by the ordering of an initial diet when a patient is assigned to a ward.

<u>Potential benefits</u>

In general, the A&D subsystem is designed to provide

--prior contact information to facilitate determining the patient's legal eligibility for care;

--patient status and location information to affected users;

--monitoring of application processing and patient movements to avoid "lost" patients and records;

--up-to-date management data, waiting lists, and scheduled admission data;

--periodic screening of records for completeness; and

--procedures to facilitate the discharge process, such as screening of record status and summary worksheets.

RADIOLOGY SUBSYSTEM

The radiology subsystem principally concerns diagnostic radiology involving doctors' orders, scheduling examinations, control of prior film information, and film reading and reporting. It includes therapeutic radiology ordering, scheduling and reporting and management reporting.

Processing

An AHIS radiology order provides for specific patient and examination identification; reason for the examination; time desired; and mode of transportation to radiology service, if required. All entries are edited and translated on the originating terminal for operator verification. After verification, AHIS automatically checks the examination scheduled and assigns an appointment day and time. Routine examinations are scheduled by AHIS at a predetermined rate per hour.

Exceptions to this process are orders for procedure examinations which are not AHIS-scheduled; instead the radiology service terminal produces a request-for-examination notice. Radiology service then manually assigns a specific appointment and enters the time from its terminal.

Appropriate notices for all types of examinations are produced in escort and dietetic services when the order affects them. Notices are also produced in radiology service when the examination is AHIS-scheduled. For all examinations, appointment slips are produced at the ordering source.

Worksheets for recording initial findings are automatically generated in radiology service before each examination. Results may then be entered directly into AHIS or may be manually dictated onto an AHIS generated radiolographic report. Initial findings for all emergency examinations are entered into AHIS and the ordering source is immediately notified.

Scheduled examination may be cancelled or rescheduled through AHIS at any time, in which case all sources affected are notified by a printed notice on their terminals. In addition, radiology service can adjust the rate at which AHIS schedules examinations. Any examination previously scheduled and affected by such an action is automatically rescheduled, and appropriate notices are produced.

Potential benefits

The design of the radiology subsystem was intended to provide

--a means for immediately requesting all types of radiology examinations, including transmitting all patient information pertinent to the examination;

--automatic and immediate notification of prior film information and duplicate orders before acceptance;

--immediate notification at radiology service of scheduled examinations, facilitating necessary preparation;

--automatic cancellation and rescheduling, including notices to all affected services;

--automatic printing of patient appointment notices;

--elimination of patient appointment conflicts and minimization of waiting time; and

--better control of workload distribution and scheduling.

DESCRIPTION OF SIX ADDITIONAL SUBSYSTEMS

LABORATORY

The laboratory subsystem processes data and communicates messages for ordering, scheduling, controlling, and reporting blood chemistry and hematology tests. The subsystem includes such features as input of machine-readable data produced by laboratory equipment using analog-to-digital data converters, automatic flagging of results exceeding normal ranges, and monitoring of test status from order through receipt of results on the ward. It produces daily summaries, as well as ward and laboratory specimen lables, for chemistry and hematology laboratory tests results for each patient.

WARD CARE

The ward care subsystem has been installed on a limited basis. It updates patient records for dental care status, seriously ill status, nursing care category, admission diagnosis, and drug sensitivities. Some functions originally designated to be included in the ward care subsystem have been incorporated in other subsystems. For example, the nursing schedule function is included in the management information subsystem.

DIETETIC

The dietetic subsystem handles communications to dietetic service, including information on the patient's initial diet and any subsequent modifications or suspensions. Input consists of such transactions as an order for a diet or special supplementary nourishment, an order for change in diet, or a diet cancellation before surgery or diagnostic procedure. Once verified and entered, the diet order initiates the printing of a diet card on the dietetic service terminal, which is used to select food for the patient as his tray moves down the diet tray assembly line. The dietetic ordering system provides for 20 primary diets which may be further defined by number of calories, amount of protein, and consistency.

The subsystem also produces several consolidated reports, including a dietetic action schedule for nursing service; a list by ward of patients by bed number, type of diet, and meal status; and a consolidated census by type of diet for dietetic service.

CLINIC

The proposed design for the clinic subsystem included the ability to request and schedule the services of offward clinics and laboratories for bed patients and outpatients. However, as presently implemented, this subsystem is limited to scheduling dental examinations for patients who have not previously had them. This function includes the printing of dental appointment slips on the appropriate ward terminals.

PATIENT INFORMATION

The patient information subsystem provides for the printout of patient management information on a recurring basis and for the retrieval of selected data in a patient's file. All data which can be retrieved has been entered through another subsystem. Examples of such data are a roster of seriously ill patients, a patient directory, clinical data, administrative data, patient status, and active X-ray orders.

MANAGEMENT INFORMATION

The management information subsystem is designed to accumulate statistics and other data from AHIS operations and provide this information when needed to appropriate hospital personnel. It maintains and produces such information as a patient roster by States, outpatient visit statistics, nursing service schedules, and staffing lists.

ADP SYSTEMS IN OPERATION AT VA IN SUPPORT OF

MEDICAL AND VETERANS' BENEFITS PROGRAMS

FISCAL YEAR 1971

Integrated Engineering System
Specification Preparation System
Clinical Laboratory (Boston VA Hospital)
Clinical Laboratory (Minneapolis VA Hospital)
Automated Hospital Information System (Washington VA Hospital)
BioPhysical Monitoring
Allocation of Facilities
Patient Treatment File
Logistics System
Engineering Performance and Inspection
Prosthetics Inventory Control
Multiple Laboratory Testing
Construction Requirements Data
Fee Basic Medical
Personnel Data and Pay System
Automated Management Information System
Supply and Dietetics
Patient Census
Pharmacy Inventory
Nutritive Analysis
Centralized Accounting
Compensation and Pension System
Insurance System
Education System
Beneficiary Identification and Records Locator System

INVENTORY OF AHIS EQUIPMENT

Manufacturer	Type and Model	Description	Number (including spare units)	Comments
IBM	026-1	Printing card punch	1	
	526-1	Printing summary punch, Alpha	1	
	1051-2	Control unit	45	
	1052-2	Printer keyboard	43	Includes four units as spares
	1052-7	Printer keyboard	1	Serves as a computer console
	1053-1	Printer	9	Includes two units as spares
	1056	Card reader	1	
	1092-2	Programed keyboard	39	
	1093-1	Programed keyboard	5	
	1403-2	Printer	1	
	1442-N1	Card read punch	1	
	2040-H	Processing unit	1	Contains 262,144 bytes of main memory
	2711	Line adapter unit	1	
	2803-1	Tape control	1	
	2821-2	Control unit	1	
	4790	Line adapter	16	
	4794	Line adapter module	3	
Calcomp	CD14	Disk control	1	
	CD22	Disk drive	5	Includes one unit as a spare
AMPEX	1624-11	Magnetic tape unit	3	

Manufacturer	Type and Model	Description	Number (including spare units)	Comments
Infotronics	CRS-75 S	Digital readout system with card punch interface and card punch buzzer	1	
Non-linear	1810 SP	Card punch interface	1	
Memorex	1240	Communication terminal	1	
	1270	Terminal control unit	1	
	1221	Modems	16	
	Mark 6	Disk pack	4)	Each disk pack
Computron	1100	Disk pack	9)	provides 29,186,000
Nashua	4411	Disk pack	8)	bytes of storage

- - - -

Computer terminal configurations	Number
1. 1-1051 Control unit, 1-1052 Printer keyboard, 1-1092 Programed keyboard	35
2. 1-1051 Control unit, 1-1052 Printer keyboard, 1-1092 Programed keyboard, 1-1093 Programed keyboard	4
3. 1-1051 Control unit, 1-1052 Printer keyboard, 1-1056 Card reader, 1-1092 Programed keyboard, 1-1093 Programed keyboard	1
4. 1-1051 Control unit, 1-1053 Printer	5
5. 1-1051 Control unit, 2-1053 Printer	1
6. 1-1240 Communication terminal	1
Total July 1, 1973 installed terminals at	47

TECHNIQUES FOR AUDITING

A

REAL TIME ADP SYSTEM

U.S. GENERAL ACCOUNTING OFFICE

Contents

CHAPTER 1

INTRODUCTION

These techniques are intended to provide a basic framework for evaluating or testing the effectiveness of internal controls in real time ADP systems and for evaluating the reliability and usefulness of system products. Since real time systems vary widely in type and complexity, the auditor must adapt the techniques to the system under audit. Auditors with some ADP training or who can have the assistance of an ADP audit specialist can use the techniques more effectively. Some knowledge of basic data processing terminology, the principles of internal control for batch processing[1] systems, and techniques that can be used in auditing computer systems would be helpful to the auditor.

AHIS at Washington VA Hospital was the real time system studied during the development of these techniques, and many of the audit tests and techniques discussed herein were applied to it.

Assistance in developing a program for a specific assignment is available through GAO's Financial and General Management Studies Division.

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[1]A technique by which information to be processed must be coded and collected into groups before processing.

CHAPTER 2

PRINCIPLES OF REAL TIME COMPUTER SYSTEMS

DEFINITION

Real time systems process data in a sufficiently rapid mânner that the results of the processing are available in time to influence the process being monitored or controlled. To achieve real time response, information is maintained on-line[1] and updated as events occur. The computer equipment center is usually connected to remote terminals or other devices.

Response time is the interval between a terminal operator's pressing the start key and terminals' beginning to type the reply--in other words, the interval between the input of an event and the system's response to the input. Authorities differ on the length of response times which delimit real time systems and non-real time systems. A reasonable point of view seems to include responses of several milleseconds to several minutes as acceptable real time responses.

ADVANTAGES OF A REAL TIME SYSTEM

The following discussion of advantages of a real time system should indicate the importance of this level of technology and may help convince the auditor that this is a worthwhile area in which to develop audit competence.

Integration of functions, decisions, and files

A real time system can integrate separate functions, such as project planning, inventory control, and payroll within an organization, and data from different sources can

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[1]On-line refers to peripheral equipment connected to and capable of interacting with the central processing unit of the computer. Data maintained in on-line systems are immediately accessible to the central processor and usually stored in a random storage file, such as a magnetic disk or drum.

be efficiently referred to in making decisions. Also, integrating an organization's files within one system eliminates duplicate data collection and storage.

Geographic centralization

Organizations which are geographically dispersed can benefit from a real time system with data transmission links to outlying branches. Examples of such systems are those used in making airline reservations and in tracking satellites.

Information retrieval

The information retrieval service provided by a real time system is necessary for a system such as a scientific or medical information exchange. This service could also be of benefit to an inventory or other control system.

Data collection

A real time system may provide a data collection service by scanning instruments in a process control system or by assembling information received from human terminal operators.

Communications

A real time system has the potential for providing an information routing service in an organization. Communications can be faster than mail service and more efficient than voice communications.

Fast action capability

Fast response and turnaround times of a real time system can do much to improve customer service and provide the speed required in certain defense or process control systems.

Controlling environment

The ability of a real time system to control a factory production line or petroleum plant can increase efficiency or production.

Combining computer and manual processing

A real time system can combine computer and manual processing when it is desirable to include human experience in decisionmaking. Examples of this are airline flight control and the Semi-Automatic Ground Environment air defense network.

Eliminating intermediate steps

Using real time systems can eliminate intermediate steps, such as punching cards or printing lists, by providing data collection at the source and delivering the output to where it is to be used. This can be done by a factory time recorder or a bank teller keying transactions. Eliminating intermediate steps can reduce computer costs and minimize errors.

Centralized processing for many users

Real time techniques allow many different users to share one large computer instead of incurring excessive costs to maintain their own small computers. Thus, users who could not otherwise afford a computer benefit from the processing capability and centralized files available from a service bureau or other shared computer system.

CHARACTERISTICS OF REAL TIME EQUIPMENT

A real time system does not necessarily require a specially built real time computer. With the appropriate random access files and other peripheral equipment, many off-the-shelf computers available today are used for real time processing. Certain desirable features, discussed below, are available on some computer equipment and add to the efficiency of a real time system.

Computers

The computer selected should have adequate storage capacity, a fast processing speed, and allow for adding storage capacity. The requirements for these features must be estimated during the system design phase.

A computer also should have an interrupt system so that the arrival of a transaction or the completion of an input/output operation will interrupt the program in core while a different program is executed to service the interrupt condition, and when the interrupt processing is completed, processing will return to the interrupted program.

To store the input transactions which tend to arrive intermittently during real time processing, it is necessary to provide for input/output buffering. The primary purpose of a buffer is to provide a storage device to compensate for a difference in data handling rates when transmitting data from one device to another. Some computers use a portion of main core storage for buffering. In some telecommunication systems, buffering is achieved by using a separate computer which handles all communication lines.

The computer should be able to dynamically relocate programs during real time processing. Dynamic program relocation means that a partially executed program can be moved to another core storage location while normal processing continues. This capability allows the size of the core storage to adapt flexibly to the varying demands of the system.

Generally, real time systems have multiple programs residing in core storage at the same time and users can enter data and, in some cases, programs from terminals. In such an environment, it is desirable to have a storage protection feature to prevent one program from destroying or changing another program. One method is to divide core storage into blocks in which each program must confine its activity.

Real time systems generally serve multiple users who use the system on a random basis by sending messages over communication lines. Consequently, equipment and programing are necessary to handle the multiple inputs. This requires features which provide for controlling data received from the lines, polling terminals, assembling characters into messages, and checking for transmission errors.

Terminal devices

A real time system is communications oriented and provides fast responses to multiple users. A terminal is a device, connected on either end of a communication channel or line, where data can enter or leave the communication network. A familiar example of a terminal is a teletype, which consists of a keyboard, paper tape, a printer, and sending and receiving equipment. Many other terminal devices can be used in a real time system. Some terminals may have specially designed keyboards or use plates, cards, or paper tape for data entry; others use a cathode ray tube to facilitate data input and output.

Some considerations for a terminal are security, speed of response, size and enviromental requirements, and provisions for visual input verification and hard copies. Chapter 3 discusses visual input verification and terminal security in more detail.

REAL TIME TECHNIQUES

Coordination of computer activities, control of communications, and fast response time are achieved through the interaction of sophisticated hardware and processing techniques. Processing techniques commonly used for real time operations are not limited to real time systems but may also be used in complex computer installations and time-sharing sytems. These techniques fall into the categories of supervisory programs, multiprograming, and polling.

Supervisory programs

Operating a real time system requires coordinating input and output activities, scheduling processing activities, and controlling interrupts. A programer cannot anticipate these activities and must handle them on a random basis according to the demands on the system.

Supervisory programs perform these activities, communicate with the computer operator, allocate core storage, select and call in the required programs, control time-initiated actions, and initiate fallback and recovery procedures. Supervisory programs are sometimes referred to as the control program, the monitor, the operating system, or the executive.

Multiprograming

Multiprograming enables many users to share a large computer, increases the productivity of computer hardware, and permits real time response from a computer.

Multiprograming involves executing two or more programs in a computer. The programs share the computer'' processing time in a sequential manner although it appears to the users that the programs are being executed simultaneously. This is done by interrupting the execution of program A to execute a portion of program B while time-consuming file searches or input/output operations are taking place to service program A. This interruption and partial processing continues for as many programs as provided for, until processing control returns to program A. Thus, two or more programs may be partially completed in core storage at any one time while the supervisory programs are most efficiently using the computer's resources.

Polling

Polling involves consecutively interrogating every terminal on a shared communications line to determine whether the terminals have messages to transmit to the computer. Polling is assigned to a central station, such as a communications controller, to avoid multiple transmissions at the same time. The central station interrogates each terminal, in turn, and sends a proceed signal to the first requesting terminal it encounters. The computer may have a polling list which tells it the sequence in which to poll the terminals. For example, a terminal requiring higher priority service may be listed more than once on the list so that it is polled more frequently than the others.

CHAPTER 3

AUDITING REAL TIME SYSTEMS

This proposed audit approach includes four phases (1) understanding the objectives of the system, (2) identifying and evaluating internal controls, (3) testing internal controls and system operation, and (4) evaluating the adequacy and use of system products. When auditing real time systems, the auditor must rely more heavily than usual on internal control. Consequently, a greater portion of his audit effort must necessarily be directed toward this part of his audit.

UNDERSTANDING THE SYSTEM

This phase uses techniques already familiar to the auditor, such as interviewing agency personnel, attending briefings, obtaining documentation, and observing the system in operation. During this phase, the auditor should evaluate the

--objectives, scope, and limitations of the real time system;

--characteristics of the system which classify it as real time and how it helps to achieve the mission or objectives of the organization;

--planning which preceded installation of the system, such as studies of feasibility, transaction volumes, and vendor equipment, and software;

--future plans for development or change;

--organization of the agency or entity being reviewed, particularly those organizational entities which (1) designed and developed the system, (2) operate and maintain it, and (3) are served by it;

--inventory of the system hardware and software, particularly special software packages which may be useful to the auditor. The auditor should become familiar with the capabilities and operating characteristics of the hardware, the type and nature of the supervisory programs (operating system) and the available assemblers and compilers;

--narrative description of the system, including all applications installed and planned for installation. This should describe records and files used, how applications interrelate to one another, and potential benefits;

--system or subsystem flow charts which identify all input documents, records, programs, files, and output;

--copies of other descriptive design documents and operating instructions;

--narrative descriptions of all computer programs, copies of record and file layouts, and samples of source or input documents, records, messages, and reports resulting from processing operations;

--qualifications and experience of the system designers, programers, and operators;

--one-time costs, including systems and procedure study, site preparation, recruiting, and installation and start-up; and recurring costs, including hardware rentals, maintenance, salaries, and overhead.

After achieving a basic understanding of the system, the auditor should be ready to proceed with the internal control phase.

IDENTIFYING AND EVALUATING INTERNAL CONTROLS

Internal controls in a real time system should (1) safeguard assets, (2) reasonably insure accurate processing, (3) promptly detect errors and irregularities, and (4) take corrective action. Controls should be designed to prevent the manipulation of the system and insure the integrity of the data input, files, and output.

Identifying and evaluating internal controls is important because it allows the auditor to draw tentative conclusions about the reliability of the system and to select controls eligible for testing. The results of the tests performed will confirm or modify the tentative conclusions.

Five main categories of internal controls are discussed in the following sections. Specific questions are also provided to guide the auditor's evaluation. The questions are not intended to be all inclusive and will require modification by the auditor.

Organization and management

Evaluating the organization and management of the activities supporting the real time system is a major step leading to conclusions about the system's efficiency and effectiveness. Considerations in this area include internal audit or other independent evaluation of the system, project control techniques, separation of duties, competence of personnel and other factors affecting their performance, quality of system and program documentation, and program modification and correction procedures.

Independent audit or control group

Independent groups auditing or controlling the real time system should be evaluated and if these groups do not seem adequate, appropriate recommendations should be made. Independent review may be an internal audit, a systems audit, or a control group.

A systems audit was made during the installation of AHIS at the VA Hospital. Systems auditors were responsible for certifying the operational status of all AHIS computer programs. They reviewed program documentation and tested the operation of each program; and, when they were satisfied with test results, a memorandum of certification was added to the formal program documentation and the program was ready for installation.

Effective control of batch processing often includes use of a group, independent of the users and computer personnel, to control data entering and leaving the data processing activity. Real time processing, with decentralized input arriving at the computer from a communications network, eliminates the need for manually balancing input totals. However, a control group can still be used to evaluate the reasonableness and quality of system products. The control group's responsibilities could include monitoring the system's operation and verifying that it is efficently used and adequately controlled.

Questions

1. Identify the group responsible for the internal audit or control of the real time system and determine its position in the organization. Is it independent of the officials and personnel responsible for operating the system?

2. Obtain and review copies of internal audit reports. Are the findings significant and is corrective action being taken?

3. Did internal auditors or a control group help to design or to provide an audit survey of the ADP system? If so, they should have detailed knowledge of the internal controls.

4. Does an independent group monitor the quality and reasonableness of system products?

5. Are the effectiveness of controls and the effectiveness and use of reports, notices, and other outputs of the real time system reviewed?

6. Does an independent group certify computer programs as operational?

Project control techniques

Planning, designing, and implementing a real time system involves the coordination of many personnel and activities. The auditor should know how the system was divided into workable subsystems, how development of these subsystems was controlled, and what real time testing the system has undergone.

Questions

1. How was the system divided into subsystems or applications?

2. Was a feasibility study prepared for the system as a whole or for each subsystem?

3. Is a schedule maintained showing actual implementation compared to planned progress?

4. Are periodic, detailed progress reports prepared for management?

5. What type of planning preceded final program testing?

6. What test data were used and what were the results of testing?

7. Were parallel operations conducted? What were the results? How were discrepancies resolved?

Separation of duties

An appropriate separation of duties among systems designers and programers, computer operators, personnel who maintain ADP documentation and files, and personnel who initiate transactions is necessary to insure adequate control. This is particularly important in a real time system processing financial data or controls assets.

Questions

1. Are the functions and duties of system designers and programers separate from computer operation?

2. Are two qualified operators on duty in the machine room during all processing as a check against unauthorized use of the computer?

3. Are computer operators restricted from access to data which is not necessary for performing their job?

4. Are computer personnel restricted from access to terminals which are capable of originating transaction input?

5. Are computer operators rotated periodically?

6. Are operators closely supervised to insure adherence to prescribed operating procedures?

7. Are the data processing files (magnetic tape and disk) controlled by a librarian?

8. Are copies of computer programs maintained in the library and issued to interested parties only on written authorization?

Personnel

Design and development of a real time system requires skilled designers and programers working together as a team. It is probably more economical to use highly skilled personnel than to use a large number of less experienced people. Furthermore, it is desirable to retain skilled personnel as long as possible to insure continuity in system efforts and to prevent design and implementation slowdowns.

Questions

1. For the system's managers, designers, and programers, determine names, position titles, civil service classifications, job descriptions, qualifications, and experience. Do these personnel appear to have educational and experience qualifications in line with their job descriptions?

2. What is the rate of personnel turnover in the real time system? Has this caused any problems?

3. Does a formal training program exist? What training requirements are personnel expected to meet?

Documentation

The need for comprehensive ADP system documentation has been discussed in other GAO publications, such as part IV of the "Comprehensive Audit Manual" and "Case Studies of Auditing in a Computer-Based Systems Environment." Complete and accurate documentation is important to management and auditors because of the complexity of real time systems. Lack of such documentation can substantially increase the audit effort required.

Questions

1. Does documentation adequately describe the real time system?

   System documentation generally should include

   --overall system flow charts;

   --narrative description of the objectives, scope, limits, design considerations, and general system operation.

2. Is program documentation complete, accurate, and current? Such documentation generally should include:

   a. A program specification summary or narrative description of program functions.

   b. A description of primary program edits.

   c. Block diagrams showing the sequence of program operations.

   d. Record layouts.

   e. Program listings.

   f. Corrections and modifications to the program.

   g. Special operating instructions.

   h. Exhibits showing report formats or other information.

   i. Test data and results.

3. Are detailed operating instructions available? Such instructions generally should include:

   a. Identification of all machine system components.

   b. Procedures for starting up the system.

c. How to recognize various types of system failures.

d. Recovery procedures.

e. Procedures for shutting the system down.

f. How to deal with users.

g. Checkpoint procedures.

h. Set up instructions for special reports or jobs.

4. Is documentation subject to periodic supervisory review to insure that it is complete and current?

Program modification and correction procedures

All modifications and corrections to programs should be accompanied by the same documentation, testing, and approvals required for new programs. Reasons for changes should be supported in writing and the change should be described. Responsible personnel should approve all changes.

Questions

1. Who is responsible for authorizing modifications? Are changes authorized in writing? Is each modification properly approved?

2. Are the reasons for change and effects of the change well documented?

3. Is program documentation revised to conform to modifications? Partial revisions may be practical when changes are small, but a major change may require completely revised program documentation.

4. Are periodic checks made to insure that no unauthorized program changes have been made?

5. Are program modifications subject to the same certification requirements as new programs?

Input controls

Input controls are established to insure proper recording of all transactions at the points of origin and proper transmission to the processing points. To evaluate these controls, the auditor should become familiar with the (1) types of source documents used or other bases for originating real time transactions, (2) type of terminal used for transmitting transactions to the processing point, (3) procedures for operating the terminal devices, and (4) various controls for insuring input accuracy and completeness.

In some real time systems, conventional source documents may still be used without causing problems when data is entered at the terminal. In other systems the printed document produced by the terminal becomes the source document and may be subjected to supervisory review or authorization.

Generally, the methods used to control input in batch processing systems will not apply to real time systems;[1] except when transactions are entered from an on-line machine in batches or when an operator accumulates control totals as transactions are entered.

Techniques for controlling input to a real time system include (1) controlled access to terminal devices, (2) visual input verification, (3) programed edits or techniques designed to assess the validity and accuracy of transactions, (4) maintenance of a transaction log, (5) automatic checking of the terminal transmission to the processing point, and (6) off-line file scannning.

Controlled access to terminals

Access to and use of terminals should be controlled to minimize unauthorized or improper use. One method prevents physical access to the terminals by keeping them in locked rooms or locating them in areas inaccessible to unauthorized users. Another method provides each authorized user with a

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[1]In these systems the accumulated control totals can be transmitted in the last item of data and automatically compared with the total items received by the computer.

key, card, badge, or code which identifies him to the real time system and which is entered on all transaction logs and source documents the terminal creates.

Questions

1. Is physical access to terminals restricted to authorized users only?

2. Are authorized terminal users identified to the system by devices such as keys, badges, cards, or user codes?

3. If user codes exist, are they entered on all transaction logs and source documents?

Visual input verification

As a terminal operator is keying in transactions, the real time terminal should type out or display the input so it can be examined visually before the computer processes it. After verifying the input, the operator can notify the computer to continue processing. When a mistake is made, a convenient way should be provided to correct the error. For example, if the operator makes an error toward the end of a long message, it is convenient to have the capability to correct the error without reentering the entire message.

Questions

1. Do the real time terminals have a visual display of keyed-in transactions?

2. Do system procedures require terminal operators to visually verify the input?

3. To what extent are these procedures followed?

4. Can the operator easily correct erroneous input without reentering the entire transaction?

5. Does the system have a timeout capability so the system will reject input if the operator does not verify it within an established time period?

Programed techniques

Directly entering transactions at a remote terminal eliminates not only use of input controls, such as key verification of punched cards, but also supervisory review of transaction data in many instances. To compensate for this loss of manual control, numerous programed techniques can be used to determine the validity and accuracy of source data; e.g., existence, combination, completeness, and reasonableness checks.

An existence check determines whether a particular code of account is valid and active. Invalid codes will be rejected. Combination checks check the logical relationships of parts of a transaction. Completeness checks insure that a transaction has the prescribed data or that all necessary keys have been pushed. Reasonableness checks insure that transactions do not exceed specified limits or values. Programed techniques can also be used to provide caution or warning notices on the status of the record which the transaction is intended to update, but which will not cause the transaction to be rejected.

Questions

1. What programed techniques are used to insure the validity of input data?

2. Are these techniques used sufficiently to check the validity of all input data?

3. Are any special cautionary messages provided?

Maintaining a transaction log

A transaction log consists of all transactions accepted by the real time system and contains enough detail for complete reprocessing in the event of data loss or equipment failure. The log is maintained on magnetic tape, drum, or disk, and may include a system-generated serial number for each transaction, the number of the originating terminal, or a terminal operator's code. If the system is logging accounting transactions, these could be sorted into a daily transaction journal which could be used to verify master record and control account balances.

Questions

1. Is a transaction log (machine-readable) maintained for all transactions accepted by the system?

2. Are serial numbers or other types of identification added to the log?

3. For what control purposes is the log used?

4. Is the log maintained in secure storage so that it can be used to recreate current master records in the event of disaster?

Automatic checking of terminal transmission

Communication lines are subject to bursts of noise and stray signals which can cause errors in the data being transmitted. To detect these types of errors, terminal transmission should be monitored by a parity check on the data transmitted. Errors can also be detected by a longitudinal check, where one or more characters check the other characters in a word or message. When errors are detected, messages will be automatically retransmitted.

Periodic terminal line tests should be made to indicate the number of errors which may be expected. Furthermore, the computer should check each line and terminal to make sure that they are functioning.

Questions

1. What type of automatic checking is made on communication lines and terminals?

2. Are terminal line checks made?

Off-line file scanning

This technique can keep a check on the files validity or scan a log of input data. A processing run may be made during nonpeak hours to balance control totals, check for damaged records, search for duplicate records, or detect other undesirable conditions in the files.

Questions

1. Are off-line or nonreal time scans performed?

2. If so, what control totals are being balanced? What undesirable conditions are being checked?

3. What corrective action is taken?

Processing controls

Processing controls insure that programed operations are being performed as intended. Together with reliable input controls, they help to assure the auditor that satisfactory results can be expected from the system. Processing controls can be judged adequate if the hardware is in good operating condition; if programs are well designed, controlled, and tested; and if controls exist to prevent unauthorized intervention in the system's operation.

Hardware controls

Generally the auditor can assume that system hardware is properly designed and able to perform satisfactorily. He should, however, identify hardware controls included in the equipment. Commonly used hardware controls, such as parity, echo, and read-after-write checks, are discussed in the GAO June 1971 publication, "Case Studies of Auditing in a Computer-Based Systems Environment," and in "Auditing and EDP" by Gordon B. Davis. As stated on page 59 , a storage protection feature is desirable in real time systems to prevent one program from making unauthorized changes to another.

Another method to insure satisfactory equipment performance is to determine what maintenance arrangements exist. If the equipment is leased from a manufacturer, maintenance service usually is included under the lease. In other instances, maintenance may be provided by equipment manufacturers, service organizations, or in-house staffs.

The auditor can also review the operating log, which should contain such information as hours of use, hours of preventive maintenance, equipment failures, and unscheduled maintenance. The auditor should look for a record of operating performance statistics--an accumulation of errors by type of failure--for each major systems component.

Questions

1. What hardware controls does the equipment include?

2. Does the hardware include a storage protection feature?

3. Are operators given instructions indicating action to take when a built-in hardware control detects an error?

4. Do regular maintenance agreements exist with the equipment manufacturer or service organization?

5. Is a record of operating and maintenance information (operating log) available to the auditors?

6. Is there any other evidence of equipment malfunction?

Program controls

The auditor need not learn to program or to read detailed coding to evaluate program controls. Even if he knows the programing language being used, he will use his time better by reviewing available program documentation and programing procedures.

Program controls include topics previously discussed--documentation, modification procedures, and the inclusion of programed edits--as well as the program testing of the real time system. At this point, the auditor may want to review documentation compiled during the planning and programming phase, such as programing standards, time schedules, and decisions on programing languages. He may want to identify more carefally the types of edits and other programed checks included in the programs. Also, file labeling standards should be adequate and system programs should verify that files are current or necessary.

An important consideration in evaluating of program control is the agency's program testing. The auditor may want to review in detail the planning for final program checkout, test data used, and results obtained. This interest in program testing should also extend to the period of parallel operations, the parallel processing by the real time and the manual or nonreal time systems previously used.

Questions

1. Is program planning documentation available for review?

2. What flow chart, programing, and documentation standards apply?

3. Have file-labeling standards been established and do system programs verify that appropriate files are being updated?

4. Are plans for final program checkout, test data, and test results available?

5. Were parallel operations conducted? What actions were taken to correct any resulting discrepancies?

Controls to prevent unauthorized intervention

Computer operators or other personnel having adequate supervision and properly separated duties usually could not intervene without authorization to change real time programs or results, but the possibility does exist. As additional control against this occurrence, the console typewriter can print out any unusual manual interventions, and this can be made inaccessible to computer operators and periodically reviewed by control personnel.

Questions

1. Have provisions been made for unusual interventions to be printed out on a locked console log?

2. Are console logs reviewed periodically by control personnel?

Output controls

Techniques to control the output of real time systems vary with the type and quantity of output. The main purpose of output controls is to regulate data distribution and to compare system results with predetermined information.

If the real time system produces numerous documents or reports, these may be under numerical or batch control. Output should be reviewed for reasonableness and distributed to the appropriate office. If possible, the output should be compared with data from outside the system, such as physical inventories. Output logs may also be used in systems producing quantity output and would be permanent records of all types of output from the systems. A log would be especially useful to permanently record output data displayed on cathode-ray tubes.

For data transmitted to the terminals, output controls will include those controls over the data transmitted to the terminal and restrictions on the types of data printed or displayed. For example, if the system processes sensitive data, only certain terminals may be cleared to receive that type of output.

Questions

1. Is there a system in effect that positively controls output products to insure that all such products are accounted for and received by the designated agency or activity?

2. Are exception reports of unusual transactions or abnormal processing results given to the appropriate level of management for review?

3. Do output products compare operating results with data independent of the computer processing?

4. Are persons responsible for input transactions prohibited from controlling the resultant output products?

5. Is an output log maintained, especially when outputs are displayed on cathode-ray tubes?

6. Are there any restrictions on the types of data which can be received at the terminals?

Security or disaster controls

Despite elaborate day-to-day controls built into the real time system, further measures must protect against complete loss of files, as for example by fire, and to provide alternatives in the event of prolonged hardware failure. These measures range from observing fire prevention rules to arranging for alternate facilities in the event of prolonged hardware failure or destruction of the processing system.

In some real time applications, such as air traffic control systems, continuous operation is required. To achieve this level of reliability, a duplex configuration may be used, in which the required hardware is exactly duplicated; processing can then be switched over to the backup system if the primary system fails. Such duplication of ADP facilities is costly and should be justified by the nature of the operation and the unsuitability of alternative methods.

File reconstruction is possible by maintaining an input transaction log and by taking a checkpoint whereby the status of the system and files is periodically recorded on magnetic tape. If the need arises, the system can be restarted from the last checkpoint and the status of the files made current by reprocessing the input transactions.

If the system becomes unavailable for long periods of time, bypass or standby procedures should be devised so that the activities being serviced by the real time system can continue to function until the system is operative. For example, terminal operators could temporarily use prepared listings and accumulate transactions until the system is available.

Questions

1. Are fire prevention rules enforced?

2. Is a duplexed configuration used to increase system reliability?

3. Are there provisions for the use of alternate or backup facilities?

4. Is there offsite storage for duplicate copies of documentation, programs, and files?

5. Are checkpoints taken periodically?

6. Have standby procedures been devised for prolonged system failures? Have these procedures been tested under operating conditions?

7. Is the computer room physically secure from unauthorized access? Are visitors adequately supervised?

8. Does the type of duplexed or backup facility seem reasonable on the basis of the operations and the available alternate methods of achieving disaster security?

TESTING THE SYSTEM

Many of the internal controls discussed in the previous sections can be adequately evaluated by reviewing planning and control documentation, and observing the controls in operation. For example, the auditor can observe the methods used for controlling access to the terminals and the techniques used for verifying input data.

To determine that the system is working properly and that certain input and processing controls are operating as intended, however, the auditor should develop and apply appropriate testing and techniques. He will develop these techniques from his understanding of the system and his identification of the conrols eligible for testing. During this phase, the auditor will also use his previously acquired knowledge of the availability of special software packages and program testing techniques. When the capability and need exists, the auditor may want to develop his own programs for retrieving and analyzing data.

Four techniques for testing a real time system are discussed in the following paragraphs. For maximum effectiveness, these techniques should be used to supplement each other and one technique should not be relied upon.

Monitoring

Monitoring consists of reviewing all input and output during a defined period. This technique can be implemented by obtaining carbon copies of terminal transactions and duplicate copies of reports and other output. The auditor can use this material to identify system procedures, edits, and other controls. In certain instances, he may be able to trace transactions back to source documents or forward to reports. Monitoring can lead to identifying system weaknesses of deficiencies and is helpful in evaluating the use of system products.

Monitoring alone is not a sufficient test, because the auditor is exposed only to procedures and controls that happen to be used during the monitoring period. It is necessary, therefore, to supplement this technique with one or more of the other methods.

Test decks

Using a test deck to test the procedures and controls in a computer program is often associated with evaluating batch processing programs. Real time systems programers also require some method to efficiently test program operation without using the actual terminals for input and output. The technique devised to fill this need is to simulate terminal input and output functions with a program called a test loader, terminal simulator, or test supervisor program. Input data may be stored on cards or magnetic tape and fed to the programs being tested by using the test loader. Similarly, printing output on the terminals may be replaced by storing the output on tape or printing it on a high-speed printer.

The auditor should investigate the capabilities of the test loader to determine whether he can use it effectively to test the system operation. One advantage of using the test loader is that the auditor may be able to process test data against dummy files and avoid the risk of altering or introducing error into live current files.

"Case Studies of Auditing in a Computer-Based Systems Environment," dated June 1971, includes a discussion of the advantages and disadvantages of test decks.

Sampling from the data base

Equipment on which the real time system is processed, software available, and system design may let the auditor use prewritten or specially written programs to select real time data for audit. One method would be to select transactions from the transaction log and develop audit steps that would indicate whether these transactions had been properly edited and processed. A step in this evaluation might be to obtain copies of master records before processing and compare them with copies of master records after processing the transactions. This technique would have the same disadvantage as monitoring, in that only transactions processed during the period would be eligible for selection. If time permits, sampling techniques might be used for testing transactions over a long period.

On-line testing

Devising and entering test transactions from a terminal during live system operation is the most effective method for testing programed procedures and controls in a real time system. However, it is important to use only transactions which will not alter the data base or otherwise disrupt the system's operation. This limits the auditor tests to transactions which are designed to violate known system edits and which will be rejected. Another alternative is to use the information inquiry capability of the real time system wherein the auditor can effectively make system inquiries during live processing with little or no risk to the data base.

Any plans to perform on-line testing should be closely coordinated with the appropriate real time system personnel.

EVALUATING THE USE OF SYSTEM PRODUCTS

Specific guidelines for evaluating system products will necessarily depend upon the objectives and nature of the real time system being audited. During the preceding three phases of this audit approach, the auditor should have made some preliminary judgments as to how well the real time system fulfills its objectives. Evaluating the use of specific system products will further substantiate these preliminary judgments and will help the auditor to determine whether potential benefits have been realized. One method for evaluating the use of system products is to

--select products for evaluation,

--investigate the use made of each product;

--discuss the value of the product at the user level,

--determine whether users react favorably to the system or whether they would prefer to use manual methods or the former system; and

--obtain users' suggestions for improving the system.

Applying this test or others devised by the auditor should lead to conclusions as to whether products are being used as intended and whether the system is meeting its objectives effectively.

APPENDIX X

BIBLIOGRAPHY

BOOKS

Davis, Gordon B., Auditing and EDP, American Institute of Certified Public Accountants, 1968

Head, Robert V., Real Time Business System, Holt, Rinehart, and Winston, 1964.

Jordain, Philip B., Condensed Computer Encyclopedia, McGraw-Hill, 1969.

Martin, James, Design of Real-Time Computer Systems, Prentice-Hall, 1967.

Martin, James, Programming Real-Time Computer Systems, Prentice-Hall, 1965.

Murdick, Robert G. and Joel E. Ross, Information Systems for Modern Management, Prentice-Hall, 1971.

Schoderbek, Peter P., Management Systems, John Wiley and Sons, 1971.

Stimler, Saul, Real-Time Data Processing Systems, McGraw-Hill, 1969.

Weik, Martin H., Standard Dictionary of Computers and Information Processing, Hayden, 1969.

Withington, Frederic G., The Use of Computers in Business Organizations, Addison-Wesley, 1971.

PERIODICALS

Brown, Harry L., "Current Problems of Real-Time Auditing," Management Accounting, May 1969.

Lewis, William F., "Auditing On-Line Computer System," The Journal of Accountancy, October 1971.

Moore, Michael R., "EDP Audits: A Systems Approach," The Internal Auditor, May/June 1969.

Ross, Franz E., "Internal Control and Audit of Real-Time Digital Systems," The Journal of Accountancy, April 1965.

Thorne, Jack F., "Internal Control of Real-Time Systems," Data Management, January 1971.

Yourdon, Edward, "Reliability of Real-Time Systems," Parts 1-6, Modern Data, January-June 1972.

OTHER PUBLICATIONS

Automatic Data Processing. Comprehensive Audit Manual, Part IV. U.S. General Accounting Office

"Case Studies of Auditing in a Computer-Based Systems Environment." U.S. General Accounting Office, June 1971.

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