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MEDICAL INSTRUMENTATION LINKAGE SYSTEM (MILS)

FINAL REPORT

July 1972

U.S. Army Medical Research and Development Command
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13. ABSTRACT

A Medical Instrumentation Linkage System (MILS) has been developed and placed in operation at William Beaumont General Hospital, El Paso, Texas. The system consists of a computerized clinical laboratory with direct communication links to hospital ward terminals. Data base and multiprogramming techniques have been applied to provide an online, realtime system responding to multiple users simultaneously.

The Executive Summary provides a project overview and system introduction.

The System Description (Volume I) contains a presentation of the technical features of the computer system and laboratory applications.

The Operating Procedures (Volume II) provides user instructions.

Program Documentation (Volume III) contains the programming detail at the individual module level.

Installation (Volume IV) defines the equipment, instrumentation and cabling installed for the system. Physical planning requirements are included.

Improvements in operating efficiencies have been attained. Evaluation of the system may proceed in an operational setting. Modular concepts included in the system design will permit extension of the current features or the addition of other applications.

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8. Multiprogramming for the Computerized Laboratory						
9. Real Time Systems						
10. Laboratory Information Base						

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FOREWORD

The Medical Instrumentation Linkage System (MILS) has been documented in several volumes to serve a broad range of reader interests. This Final Report presents an overview of the system, the task, the hardware and the programming. It provides an introduction for readers desiring to gain a more detailed knowledge of the system.

The System Description, Volume I, describes MILS design concepts. Major categories are included to describe laboratory applications, ward communications, multiprogramming concepts and data base organization. This volume is intended to serve the technical needs of computer system analysts and laboratory personnel interested in function specifics.

Operating Procedures, Volume II, provide the instructions for all areas of system operation—admissions, laboratory functions, ward communications and the computer room. The objective of this volume is to provide a personnel training aid as well as a procedure reference for the non-routine situations.

Program Documentation, Volume III, presents the technical detail for each programmed module in the system. This volume provides the necessary reference material for Analysts and Programmers desiring to modify the system software. Functional descriptions, detailed flow charts, and technical narratives for each module are documented. Listing of the source program code is included as an integral part of this documentation.

Installation, Volume IV, describes the physical aspects of MILS facility at William Beaumont General Hospital. The equipment placed in the various hospital locations is itemized. Physical planning data including space, environmental control and electrical specifications are included. The cabling, the instrument interfaces and the operator control boxes are included in this section. Installation and checkout instructions are included as an aid in trouble-shooting and maintaining the online data acquisition facility.

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Section 1. INTRODUCTION

The Medical Instrumentation Linkage System (MILS) is a computerized clinical laboratory system with direct, 2-way communication to hospital wards. The purpose of the MILS Project was to develop an operational laboratory information system to serve as a prototype for the U.S. Army Class II hospitals. The development and implementation has been conducted at William Beaumont General Hospital, El Paso, Texas.

The objectives of this development were directed toward improvements in patient care through implementation of new laboratory information handling concepts. Reduction in time from receipt of request to reporting of results, reduction in clerical and computational errors, improved specimen accounting practices, increased information for laboratory management, and a flexibility for change and growth were goals established for the project.

The approach which was taken was to install a centralized computer system and to develop a software system capable of supporting multiple functions in an online, realtime manner. The 1800 Data Acquisition and Control System was selected as the central system. Its hardware characteristics included the features necessary for data acquisition (digital and analog I/O), simultaneous operations (hardware priority interrupts and interval timers) and multiple peripherals operating at various performance levels (disk, tape, card, line printers, terminals, optical reader). The MPX (Multiprogramming Executive) Operating System provided the software sophistications necessary to schedule and control the multiple operations and complex data flows.

The system was designed to provide a complete "demand-response," interactive mode of operation. Operator terminals were installed at the laboratory work stations. Easy-to-use conversational methods were adopted to minimize training requirements. Instruments, interfaced directly to the central processor, provide online data acquisition. Offline test results are entered to provide complete laboratory records in the system. Inpatients and outpatients are supported so that complete specimen accounting, patient reporting, and laboratory reports are accommodated. Communication terminals provide online immediate (query) access to laboratory results, remote online entry of test requests, and remote printing of test results.

Special consideration was given to the structure of the data base so that the desired response criteria could be fulfilled. A data base organization has been designed to support collection, inquiry and retrieval of data in various forms from multiple sources. The files were structured and indexed so that patient records, specimens in the laboratory and laboratory results may be interrogated at any time and retrieved for truly current information. Patient History Results, Laboratory Statistics, Quality Control, and Patient Census are typical of other files which may be accessed for realtime reporting needs. A patient orientation is used for the storage and accessing (location and retrieval) of laboratory results. This patient identification is "chained" to corresponding laboratory records. Other chains can easily be appended if other patient oriented data were to be included in the file (radiology records, patient history, physical examination results, etc.).

The system interacts with each step in the laboratory test cycle—Admission (if inpatient), Test Requisition, Laboratory Test Performance, Laboratory Review and Return of Results (Figure 1). Although the process is cyclical for each specimen, the many sources of requisitions and the variations in test complexity dictate that every step in the basic cycle be in

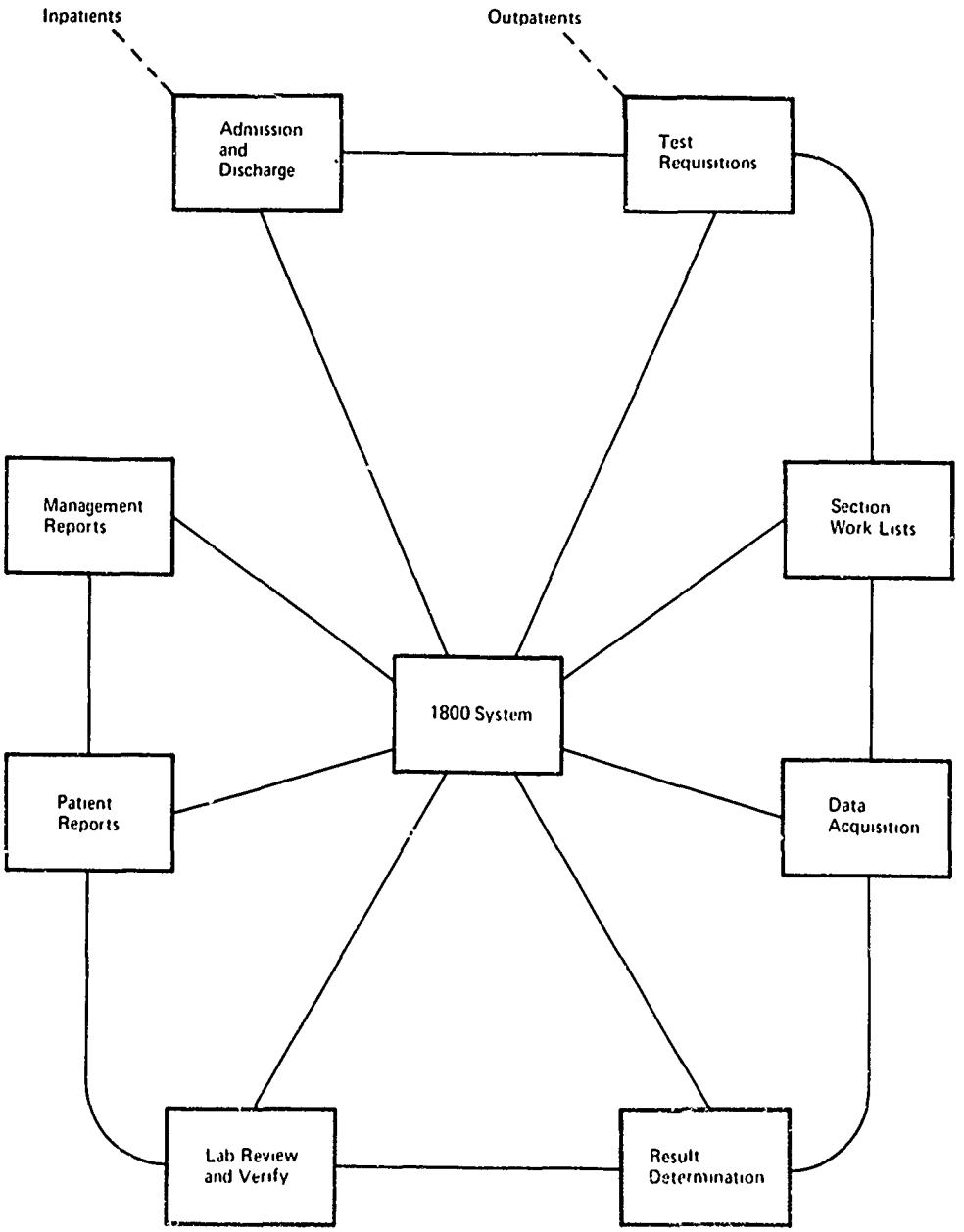

Figure 1. Laboratory Data Flow Basic Test Cycle

operation at the same time. Each transaction (instrument output, patient admission, test requisition, etc) is processed on an "in-line" basis as the data is available. Pertinent files are updated as each transaction is completed with no "batching." Therefore, patient, test, and specimen data is always current and the information provided in response to inquiries (laboratory or ward) reflect the latest status. Interim or working reports prepared for the wards or laboratory similarly reflect the status as of the time of printing.

The Basic Test Cycle requires a variety of information-handling functions. These system functions have been developed as discussed below to support these needs.

2.1 ADMISSION AND DISCHARGE

Admission and discharge of inpatients is performed throughout the day. Terminal cable length accommodates installation in the Admissions Office. Patient identification is entered into system files using interactive, conversational terminal techniques as patients are admitted. This patient is online (with his identification in the system files, available for processing) until he is discharged. Entry of patient identification in this manner establishes a master record for support of immediate lab requisitions. Changes may be made in the identification data after the initial entry has been established. When a patient is discharged his complete laboratory record is transferred to magnetic tape.

2.2 TEST REQUISITIONS

Two modes of entering requests for laboratory tests are supported—mark sensing and typewriter keyboard. The mark sense sheet is used for inpatients whose identification is on file. The desired tests and patient's ID number (Social Security Number) are marked with a standard number "2" pencil. Test sheets are designed to record results manually if a backup mode of operation is in use. Outpatient requests are specified on the typewriter terminal. Complete identification consisting of name, SSN, age, and sex are typed as are clinic and doctor's numbers and the desired tests. Optional entries of patient rank, organization or duty status may be included. When entered this data is carried forward and printed on the laboratory report.

2.3 LABEL GENERATION

Labels are generated for both inpatients and outpatients. Use of a common label provides a uniform document for laboratory personnel. The label is a 4" x 8-1/2" label stock with 10 individually removable gummed tabs. The system assigns the accession number and prints the same number on all tabs to accommodate multiple tubes and separation steps. The patient's name, identification, location, age, sex, and the requested tests are printed on this label. The specimen, type of container, and the volume are determined by the system and printed on the label.

2.4 COLLECTION SCHEDULE

Requisitions entering the system may be marked for collection. These are retained in a collection file until the next printing of the collection schedule. Collections may be performed once each morning or several times throughout the day. The standard laboratory label is printed for the collection. These labels are printed in ward and bed number sequence to eliminate manual sorting and assist the collectors on ward rounds. A terminal entry when collection is complete makes the collected specimens available for laboratory scheduling. Specimens may be indicated as not collected. A notification of a late collection is supported by the system.

2.5 PROCEDURE ASSIGNMENTS

Each test request entered in the system is assigned a procedure for result determination. Technicians have the flexibility to override a system assigned procedure, perform the test manually and enter results. Each test is individually assigned a procedure. Procedures may be assigned uniquely for patient category (adult, infant, or child) or by type of request (STAT or Routine). A single test which is a member of a multi-test instrument may be assigned to be performed on the instrument or to be performed using a manual method. When a request for a single test is performed on a multi-test instrument, only the specific request is reported, although the other results are stored in the system and can be reported if desired.

2.6 LOAD LIST

Load lists are associated with the online instruments and are printed on the laboratory terminals when requested. A load list provides a schedule of all work to be performed on the specified instrument (SMA 12/60, Glu/Bun, etc.). Positions of standards, controls, water blanks, and patient specimens are indicated. Position of these items is controlled by the procedure file, which is readily modified. Patient names are included on this report. The technologist follows this list in arranging his turntable. He may make changes in this assigned list using laboratory terminals. The technologist initiates system data acquisition for each instrument by using a control box adjacent to his instrument. This device has easy-to-use push buttons for start/stop and status lights to show data acquisition in process and possible trouble alerts. Results are error checked, converted to concentration units and stored. On request, results are printed on the laboratory terminal. The technologist verifies this list (he has delete, modify, and rerun capabilities) making the results available for reports.

2.7 WORK LIST

A work list is printed on the laboratory terminal when requested by laboratory personnel. This list shows the pending work for tests performed on other than online instruments. The technologist indicates a specific test or battery name (e.g., NA, CA, BLGAS, LYTES, TRP). The accession number and patient's name are printed for all pending requisitions in the specified category. STATs receive special identification and are printed in red for rapid detection.

2.8 ONLINE DATA ACQUISITION

Direct data transmission has been developed for eight types of laboratory instrumentation. Additionally, direct operator communication is provided via control boxes at the instrument location. The instrumentation which is online includes: SMA/12/60, Coulter Counter, single and dual channel autoanalyzers, fibrometer, differential counter, flame photometer, spectrophotofluorometer, and a digital data entry device.

2.9 OFFLINE RESULTS

Test results obtained through use of offline instruments are accepted by the system. Mark sense sheets are used to record the test results and corresponding accession number. These results may be processed at any time individually (e.g., STATS) or in small batches as desired by laboratory personnel. The results, recorded by the laboratory personnel, bypass a keypunch or other data preparation step. In the technologist's presence, results are computer-checked

as they are read in. Any errors detected can be corrected immediately and reprocessed. A printout of the results entered is provided on request. Override capability is provided if the user detects an error on the printout. This report provides the laboratory technician with his hard copy record of test results. Eleven mark sense sheets have been devised to accommodate the wide variety of test formats. Both numeric and text information appear on patient reports depending on the type of result a test requires. The common numeric results are recorded on the 2, 3, 4 digit result sheet. The results of an urinalysis test including selection of text results are recorded on a routine urinalysis sheet. Other manual result sheets are used for miscellaneous quantitative results (several numeric answers for one test; blood gases, e.g.), selection from a list of options (negative, increased, decreased, or normal; Sulkowitch, e.g.), or combinations of numeric results and selection from a list for Body Fluid counts. Every laboratory test may be reported using the 1231 mark sense reader, thus providing back-up for on-line instrumentation.

2.10 WORKLOAD REPORT

This report is printed on request on a laboratory terminal. For the specified laboratory group the number of tests requested, the number in process, and the number completed are shown. It provides a current status of the work load for each laboratory section.

2.11 SPECIMEN RETENTION REPORT

This report may be printed at any time and is printed on the line printer. It shows the status of each specimen in the laboratory. This provides the laboratory supervisor with the overall status of active specimens. It further permits laboratory personnel to dispose of specimens with confidence that the work is complete.

2.12 DAILY LOG

The daily log tabulates all test results by patient. It is segmented by laboratory groups with inpatients separate from outpatients. It shows laboratory accession number, patient ID, patient location, test name and test results.

2.13 QUALITY CONTROL REPORT—ONLINE INSTRUMENTS

The Quality Control Values are automatically extracted and placed in the Quality Control File. The Quality Control Report is printed each day in a cumulative format showing status for the complete month. Cumulative statistics are maintained for the current month and for the life of the specific control. The daily result is compared to an historical mean and the number of standard deviations is indicated by an appropriate number of asterisks on the report.

2.14 QUALITY CONTROL REPORT—OFFLINE INSTRUMENTS

Control values are manually tabulated and keypunched for offline instruments. The cumulative report format is printed daily to eliminate manual charting. In this case the file is maintained in punched cards.

2.15 DAILY INPATIENT CUMULATIVE REPORTS

Cumulative reports are printed in two formats. Numeric results and alphabetic results expressed in five characters or less are formatted with days across the top and the test names on the left. Normal ranges are shown and tests outside of this range are flagged with an asterisk. Tests which cannot be reported in this format are printed with dates and tests arranged vertically on the sheet. Up to seven days of cumulative information is presented. Reports are printed in ward/bed sequence to facilitate distribution.

2.16 DAILY OUTPATIENT REPORT

The outpatient report contains laboratory results for one day. Normals are printed and flagged with an asterisk when outside the range. The report is printed in clinic/doctor number sequence.

2.17 MIDDAY PATIENT REPORTS (WARD REPORTS)

Reports are printed on request. Status of active laboratory work is shown. The report may be printed as frequently as desired for all wards or for specific wards as designated by the technologist. Midday outpatient reports may be printed as needed.

2.18 FILE MAINTENANCE

File maintenance programs perform the record-keeping function which allows "roll-over" processing from day to day—i.e., incomplete work remains active and is scheduled on the next request. Daily removal and repacking of information reduces overall file requirements. A file utilization printout provides a status of space available in system files. Inactive patient records (inpatients being discharged or outpatient with laboratory work complete) are written on industry-compatible magnetic tape.

2.19 LABORATORY EVENT TRAIL

As laboratory personnel perform key functions, these events are recorded on the console terminal. This provides a centralized audit print out of overall laboratory status. Instruments active or runs completed but not verified can be quickly established. The status of overall ward rounds is readily apparent. The times of key laboratory event completion are available for laboratory supervisor review at any time throughout the day.

2.20 LABORATORY STATISTICS

A daily activity summary provides the number of requests, completed, incomplete and STATs for each test. Accumulative inpatient vs outpatient workload figures are provided. History reports are printed for a variable number of months up to 12 and include ASCP (American Society of Clinical Pathologists) factors and extensions.

2.21 WARD COMMUNICATIONS

Terminals have been installed at nursing stations in hospital wards. An optical image unit with a light pen type probe is used for input functions. A typewriter communications terminal prints computer outputs. Authorized personnel may request laboratory tests or retrieve test results (either current or historical). Responses to laboratory inquiries contain the up-to-the minute status of laboratory work. STAT results are transmitted directly when completed in the laboratory. Patient reassignments may be made directly from the ward terminal.

The equipment which has been installed for the MILS Project consists of the IBM 1800 system components, instrument interfaces, laboratory communication control boxes, and communication cable. A summary of this equipment is presented in this section. The computer room is diagrammed in Figure 2.

3.1 1800 COMPONENTS

1802	CPU
1828/1851	Enclosure with Analog Input Features
1826	Enclosure with Digital Input/Output and Printer Selector Channel
1826	Enclosure with Selector Channel for 2311 and 1231
1826	Enclosure with 1816 Print Expanders
1810	Disk Storage; Program Residence
2401 (2)	Tape Drives; 9 Track 800 BPI
2311	Disk Storage; Hospital Information Base
2841	Storage Control
2821	Control Unit
1403	Line Printer
1416	Train Cartridge
1442	Card/Read Punch
1816 (5)	Printer Keyboards
1053	Label Printer
1231	Optical Mark Page Reader
1316 (3)	Disk Storage Packs
029	Keypunch
1826	Enclosure with T/P Communication Adapters (5)
1896 (5)	Line Adapters (Modems)
2740/2760 (7)	Ward Terminals

3.2 ONLINE INSTRUMENTATION

The online instrumentation consists of instrument interfaces which enable acquisition of instrument signals, control boxes for operator communication and direct data entry devices. The online devices are listed below. Figure 3 illustrates the placement by laboratory section.

a. SMA
b. SMA Control Box
c. General AA Control Box
d. A.A. #1
e. A.A. #1 Control Box
f. A.A. #2
g. A.A. #2 Control Box
h. A.A. #3
i. A.A. #3 Control Box
j. A.A. #4
k. A.A. #4 Control Box

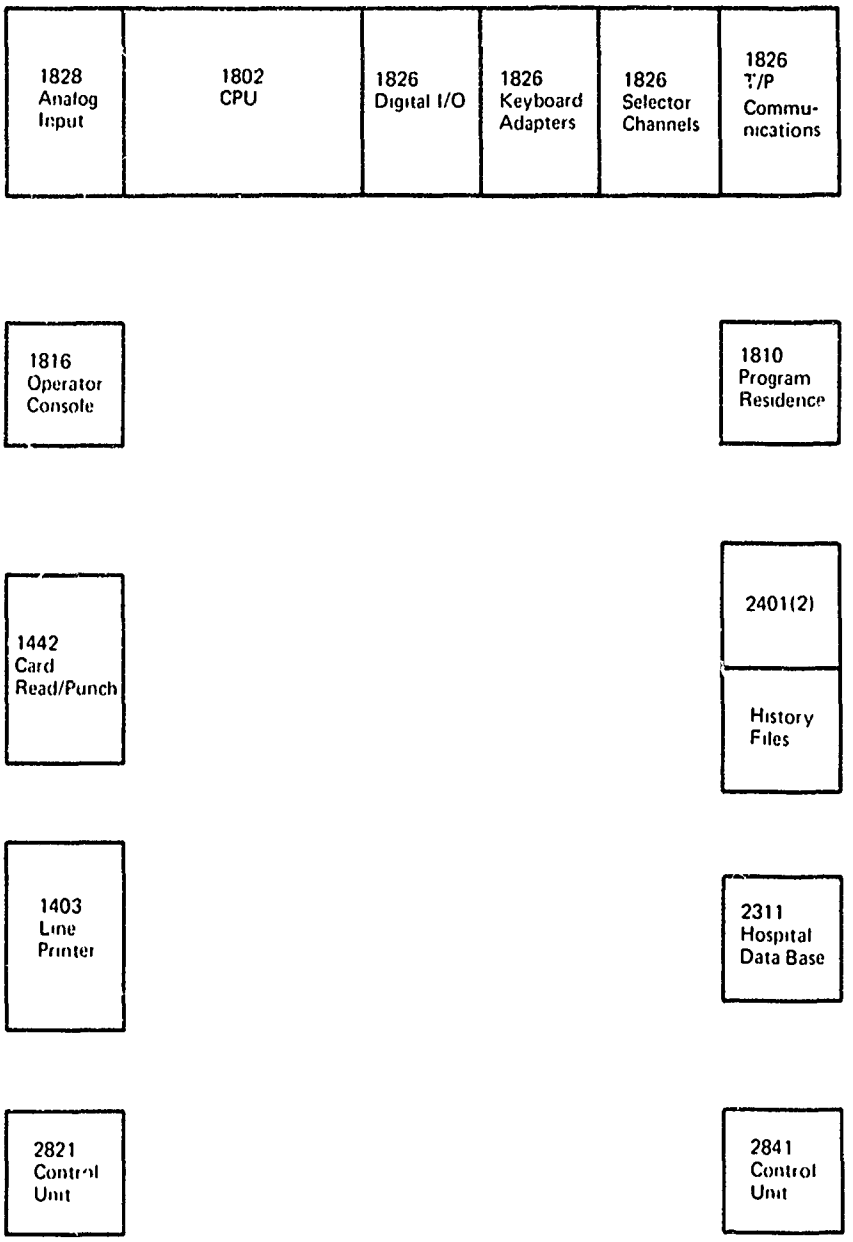

Figure 2. Computer Room Layout

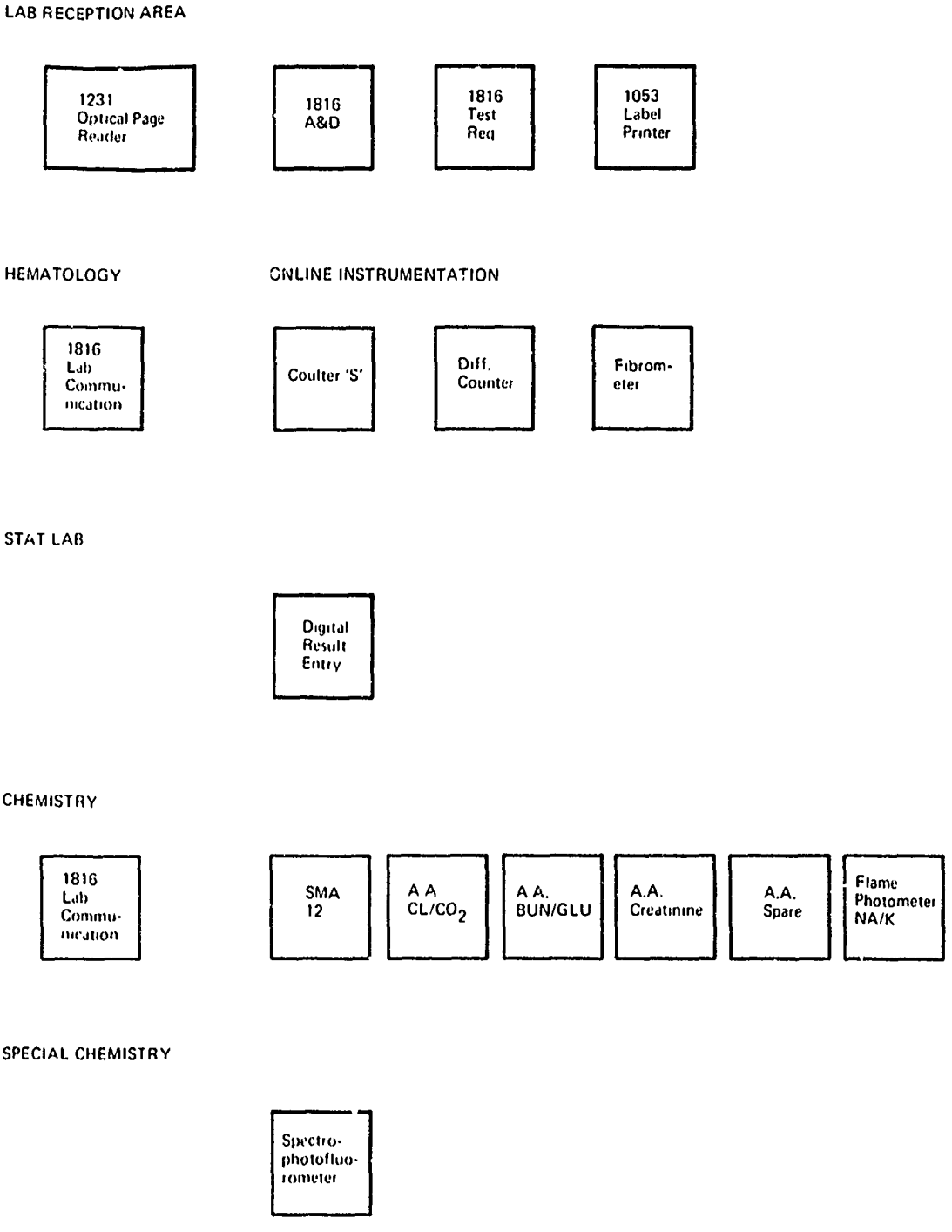

Figure 3. Laboratory Equipment

l. I.L. Flame
m. I.L. Flame Control Box
n. Aminco-Bowman
o. Aminco-Bowman Control Box
p. STAT Control Box
q. Fibrometer
r. Fibrometer Control Box
s. Differential Counter
t. Coulter "S"
u. Coulter "S" Control Box.

3.3 WARD TERMINALS

The 2740/2760 terminals have been installed for ward communications in the following William Beaumont General Hospital locations:

a. Ward 7 (Surgical ICU)
b. Ward 10 (OB/GYN)
c. Ward 22 (Medicine)
d. Ward 23 (Medicine)
e. Ward 26 (Medicine ICU)
f. Ward 28 (Medicine)
g. Computer Room.

A terminal has been retained in the computer room for use in training, for demonstrations and for use in additional developments.

4.1 REALTIME CONCEPTS

In realtime processing, the reactive software must meet response criteria imposed by the many devices capable of delivering inputs. These devices may be operational individually or simultaneously. The software must incorporate realtime concepts to support the asynchronous arrival of data and the unscheduled input from multiple users. The success of this operation revolves around detection and servicing of interrupts. Programs which receive immediate control when an interrupt occurs are constructed to execute as fast as possible. Their function is to analyze the interrupt and determine the course of action to be taken. Requirements for additional processing, resulting from each interrupt, are serviced by logging an entry (queue) for the appropriate action program. Control will be passed to the action program depending on system activity and the relative priority of this program. Meanwhile, the interrupt handler has been free to respond to a subsequent interrupt, having used only an infinitesimal time segment.

The Multiprogramming Executive (MPX) operating system was selected for MILS because it provides the features essential for the high system usage requirements of the computerized clinical laboratory. Multiprogramming is the concept which permits more than one task to be in operation at the same time. The core storage available for program execution is segmented into partitions. The MILS System has been configured to use five partitioned areas for multiprogramming with additional time-sharing of batch jobs in area 5 (VCORE). This has the effect of making one central computer look like five small ones operating under control of the Executive (see Figure 4). All five may be active at any given time, using the CPU when control is passed to it. Contention between partitions is resolved on a priority basis. A further priority level is used for multiple functions within a partition. A program in operation may be suspended due to a higher priority demand for execution. On completion of the higher priority work the interrupted task is resumed at the point of interruption. Similarly a task may be suspended while performing I/O operations. Another task, even a lower priority one, may be given control while the I/O operation is in process. Optimum use of the execution power is made since available work is being performed while data is being transferred to and from the relatively slow I/O devices. Maximum overlap of I/O with computing is attained.

MPX control provides the disk management necessary for maintaining a library of programs used in the system. It handles the cataloging when programs are added, deleted or changed. Programs are placed in the file in executable form so the dynamic allocation in response to realtime requests is handled efficiently. The use of MPX provides the high throughput and fast response essential in support of the online functions. The efficient use of processor time in execution scheduling enhances the system response to user needs. The disk management features eliminate potential program handling and storage problems. The time sharing of batch jobs makes the power of the computer available for further tasks even when the laboratory system is in an operational status.

4.2 PROGRAM SUMMARY

To accomplish the total MILS development, programs were written in these categories:

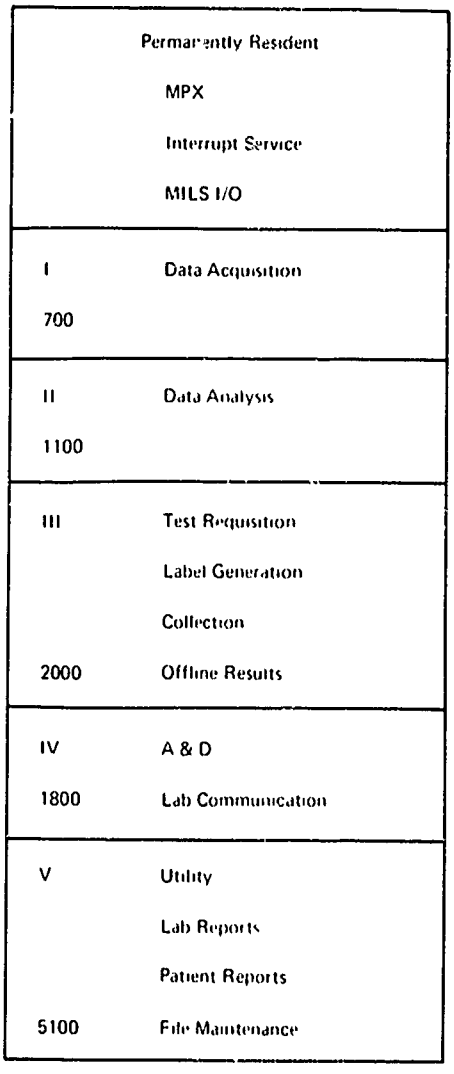

Figure 4. Core Memory

a. General system utility programs
b. Data base management
c. Ward communications
d. Admission and discharge
e. Test requisition processing
f. Laboratory data acquisition
g. Reports.

The individual programs in each category are listed in the following summary. A brief description of the function of each is included.

4.2.1 General System and Utility Programs

a. Program Utilities

1. AB53 - Convert binary to 1053 code (four digits)
2. DB43 - Convert 4-digit number to 1443 code
3. KSORT - Numeric sort subroutine
4. MB43 - Convert binary to 1443 code (five digits) and suppress leading zeros
5. MBRT1 - Print MILS error messages. Core loads:

   MBRT1 - Partition #1
   MBRT2 - Partition #2
   MBRT3 - Partition #3
   MBRT4 - Partition #4
   MBRTV - VCORE

6. RBPDS - Binary to packed decimal conversion (four digits)
7. RCVTS - Binary to 1443 (ten digits) suppressing leading zeros
8. RDMSS - Multiply double word by single word
9. RP53S - Packed decimal to 1053 conversion (four digits)
10. RPDBS - Packed decimal to binary conversion (four digits).

b. Operator Utilities

1. ABOM - Open MILS files under BOM
2. ALIN - Align printer for reports
3. ALST - Card-to-print (80/80)
4. CECLZ - C.E. coreload - print device errors
5. CHECK - Test for analog overload
6. DIAG - Digital input/output diagnostic
7. DONOF - System 1816 Online/Offline Message Printer
8. KRLD - 2311 dump/reload to/from tape
9. KTDMP - Tape dump routine
10. OLDMP - Modified system program to use PRNTN for output
11. PUNCH - Duplicate/resequence cards
12. RCIPC - Console/Interrupt core dump
13. STAR - Lab terminal online/offline message control
14. TKOPY - Tape copy routine
15. UCS - Stand-alone load UCS buffer for 1403.

c. Cold Start

1. ACPEN - Open MILS files (at cold start)
2. COLDS - Cold start teleprocessing initialization
3. DVOLT - Read power supply voltages
4. JKDWS - Day of the week computation
5. KDATE - Date initialization in common
6. KEYBI - Keyboard initialization at cold start
7. KIN - Cold start control program
8. KPROT - Protect MILS resident code at cold start.

d. Device Support:

1. 1231

K1231 - 1231 interface logic
KIOCR - 1231 interface logic
KLMSE - Error coreload for 1231
KLSLM - 1231 control coreload

2. 1816

KYBD1 - Keyboard interface subroutines. Entry points:

KYBD1 - A&D keyboard
KYBD2 - Reception area keyboard
KYBD3 - Chemistry section keyboard
KYBD4 - Hematology section keyboard
KYBD5 - Computer room keyboard

3. 1403

CUCSS - Load UCS buffer for 1403.

4.2.2 Data Base Programs

a. Operator Utilities

1. ADAC - Dump ACPAT file (indicators, etc.)
2. ADSB - Dump MILS files data set buffers (from disk)
3. ADMP - Dump MILS files lock list, data set buffers (from core)
4. ATSD - Dump specified TESTS file records
5. BOMC - Dump total Inpatient file
6. DLL12 - Load list file initializer
7. KBLST - Zero test file counts and inpatient chain pointers
8. KDBUG - Dump inpatient data
9. KLF - Initialize collection schedule file
10. TESTF - Check TESTS file record allocation.

b. Access Routines:

1. AFNDK - Find a given TESTS file entry, selective write. Entry points:

AFNDK - Search for accession #
APUTK - Update the record
AFNUK - Unlock the record

2. AFNDT - Search TESTS file and update for a given test #/accession #. Entry points:

   AFNDT - Search
   APUTT - Update

3. ARPTK - Compute the number of physical records per track for a 2311 data set
4. DSKIO - Perform disk I/O functions for MILS files. Entry points:

   DSKIO - Read, write, or lock a record
   UNLOC - Unlock a record
   ACLOS - Close the MILS files

5. KMRD - Read a miscellaneous file table
6. KMWRT - Write a miscellaneous file table
7. RAPXS - Get active patient record number.

c. Applications:

1. ABL1 - Read test descriptor cards and store them on disk
2. ABL2 - Process test descriptor cards, update TESTA, TESTB, TESTS file
3. ANIT1 - Initialize MILS files (format them, update data set buffers)
4. KMFØØ - Start file maintenance
5. KMFØ1 - Tie up Area 1 for file maintenance
6. KMFØ2 - Tie up Area 2 for file maintenance
7. KMFØ3 - Tie up Area 3 for file maintenance
8. KMFØ4 - Tie up Area 4 for file maintenance
9. KMFØ5 - Produce file usage report
10. KMF11 - Inpatient history file chain updates
11. KMF12 - Make active patient file list
12. KMF13 - Rechain and pack active patient file
13. KMF15 - Pack test file
14. KMF17 - Save outpatient history file
15. KMF3Ø - Make list for inpatient file and inpatient history file deletions
16. KMF33 - Save inpatient history file deletions
17. KMF35 - Pack inpatient history file
18. KMF37 - Pack inpatient file
19. KMISC - Create miscellaneous file control
20. KNAME - Initialize standard and control names in the active patient index file
21. KPQCM - Initialize quality control file records
22. MUSTC - Update/initialize STATS file.

4.2.3 Ward Communications

a. General Purpose Routines

1. CBLSS - Activate non-transaction unbuffering
2. CTIPS - Teleprocessing interface subroutine
3. CTPEC - Teleprocessing error processing
4. CTPMS - Teleprocessing online/offline messages
5. CTPUC - Teleprocessing restart terminal/line
6. M53LS - Convert a string of 1053 characters to line compatible code (for T/P lines)
7. MBUFS - Buffer one line of data (destined for a 2740 terminal) to disk
8. MENDS - Type a standard end message on a 2740 terminal
9. MLINØ - Supervise the buffering of T/P output. Entry points:

    MLINØ - Initialize a line buffer
    MLIN1 - Provide 2740 spacing
    MLIN2 - Buffer a string of data
    MLIN3 - Close the line buffer

10. MPIDS - Type a report heading and patient identification (name, SS#, ward, bed) for a given patient
11. MPNTS - Determine address of terminal device table for a specified T/P terminal
12. MUNBC - Unbuffer T/P data for all T/P lines (read data from disk, start the typing)
13. MWRTS - Unpack and convert a string of data and send it to a given T/P terminal
14. RENDS - Print asterisks and line feed
15. ROUTC - T/P 2760 to action core load interface.

b. Applications

1. CHWBC - Change ward/bed via 2760
2. CREQC - Test request via 2760 - error checking
3. CROSC - Ward roster on 2740
4. CRQCC - Test request via 2760 - create active patient record
5. CRQDC - Test request via 2760 - add to patient chain
6. MHS1C - Preprocess a list of selected tests and pass control to MHS2C (T/P - history results)
7. MHS2C - Build a table of history results for one test for one patient (T/P - history results)
8. MHS3C - Process a table of history results, format and type them (T/P - history results)
9. MTD1C - Current results driver 1
10. MTD2C - Current results driver 2
11. MTD1S - Process ACPAT string for a given patient, build temporary report records (T/P - STAT/current results)
12. MTD2S - Process report records, format, and type current results for a given patient (T/P - STAT/current results)
13. RST1C - STAT results temporary file data builder
14. RST2C - STAT results printer
15. RSTAC - Report STAT results on 2740 master.

4.2.4 Admission and Discharge

a. Applications

1. CAD1C - Update collection schedule file via A&D functions
2. CAD2C - Update patient identification data via A&D functions
3. KAND - Admission and discharge control
4. KANDE - Restart coreload for KAND.

4.2.5 Requisition Processing

a. Test Requisition

1. CAP3C - Area three keyword analyzer
2. CSCHC - Collection file updates for 1231 inputs
3. CUPCC - 1231 file update control - patient files
4. CUPCS - File updates subroutine - patient files
5. KLIR - Inpatient test request control logic (through 1231)
6. KLPRE - Error coreload for non-collection test requests
7. KOPRØ - Outpatient test request - operator communication
8. KOPRO - Outpatient test request - error checking and code conversion.

b. Labels

1. KLAB4 - Test request - assign accession numbers (not ward rounds)
2. KLAB5 - Test request - create active patient record and test file records (not ward rounds)
3. KLAB6 - Test request - print label (not ward rounds)
4. KLABG - Test request - exception processing (not ward rounds)
5. KLRDB - Redo a label - print label
6. KLRDL - Redo a label - locate and initialize for printing.

c. Collection

1. CSCHS - Collection schedule file updates. Entry points:

   CSCHS - Update ward/bed entry
   CSCH1 - Set collection required indication
   CSCH2 - Add inpatient record
   CSCH3 - Modify or delete inpatient records

2. KLCL - Start collection schedule
3. KLCL1 - Generate collection schedule
4. KLCLE - Restart coreload for KLCL
5. KLPIR - Audit trail for collection schedule generation
6. KLVER - Verify ward rounds.

4.2.6 Data Acquisition

a. Instrumentation Controls

1. AGAA1 - General AutoAnalyzer Control Box functions - beginning sample, delete, dilute, stop

2. AGAA2 - General AutoAnalyzer Control Box function - last valid sample
3. AGAA3 - General AutoAnalyzer Control Box function - add
4. AGAAC - General AutoAnalyzer Control Box master
5. ASMA1 - SMA Control Box functions - beginning sample, delete, dilute, stop
6. ASMA2 - SMA Control Box function - last valid sample
7. ASMA3 - SMA Control Box function - add
8. ASMAC - SMA Control box master
9. ATINP - Turn in Progress Bit On/Off in TESTS for a given accession # and test
10. D1BØØ - Coulter Counter 'S' data acquisition
11. D1BØ1 - Individual Analyzer Control Box interrupt processing. Entry points:

    D1BØ1, D1BØ4, D1BØ7, D1B1Ø - Start functions
    D1BØ2, D1BØ5, D1BØ8, D1B11 - Stop functions
    D1BØ3, D1BØ6, D1BØ9, D1B12 - Zero transmittance

12. D1B13 - SMA start/stop interrupt processing. Entry points:

    D1B13 - Start
    D1B14 - Stop

13. D1B15 - SMA channel change interrupt processing
14. D2BØØ - Coulter 'S' sequence change interrupt processing
15. D2BØ1 - Light recognize interrupt processing. Entry points:

    D2BØ1 - Coulter 'S'
    D2BØ3 - General AutoAnalyzer
    D2BØ9 - SMA
    D2BØ4 - A.A. #1
    D2BØ5 - A.A. #2
    D2BØ6 - A.A. #3
    D2BØ7 - A.A. #4
    D2B12 - Fibrometer
    D3BØ2 - Aminco-Bowman
    D3BØ5 - I.L. Flame
    D3BØ8 - STAT Box
    D3B1Ø - Differential Counter

16. D2BØ2 - Control Box message transmit interrupt processing. Entry points:

    D2BØ2 - General AutoAnalyzer
    D2BØ8 - SMA

17. D2B1Ø - SMA specimen change interrupt processing
18. D2B11 - BBL interrupt processing. Entry points:

    D2B11 - Message transmit
    D2B13 - BBL start
    D2B14 - BBL stop

19. D3BØØ - Control Box interrupt processing. Entry points:

D3BØØ - Aminco-Bowman read
D3BØ1 - Aminco-Bowman message transmit
D3BØ3 - I.L. Flame read
D3BØ4 - I.L. Flame message transmit
D3BØ6 - STAT Box read
D3BØ7 - STAT Box message transmit
D3BØ9 - Differential Counter message transmit

20. DDAOP - Digital output control routine
21. DGAA1 - Activate instrument monitoring. Entry points:

DGAA1 - A.A. #1
DGAA2 - A.A. #2
DGAA3 - A.A. #3
DGAA4 - A.A. #4
DGAA5 - A.A. #5

Terminate instrument monitoring. Entry points:

DGAD1 - A.A. #1
DGAD2 - A.A. #2
DGAD3 - A.A. #3
DGAD4 - A.A. #4
DGAD5 - A.A. #5

b. Online Data Acquisition

1. DAAPK - AutoAnalyzer peak picker
2. DAARP - AutoAnalyzer peak wrap-up
3. DCCSC - Coulter 'S' results wrap-up
4. DEMSP - AutoAnalyzer error messages
5. DSCAN - AutoAnalyzer analog read
6. DSMAO - Activate/deactivate SMA data collection. Entry points:

DSMAO - Activate
DSOFF - Deactivate

7. DSMAS - SMA analog read
8. RABSC - Aminco-Bowman wrap-up
9. RBBLC - BBL wrap-up
10. RCJ2C - STAT Entry Box wrap-up
11. RDCMC - Differential count/morphology wrap-up
12. RESUL - Compute results of load list
13. RILFC - I.L. Flame wrap-up
14. RUTAS - Update files for non-load list instrumentation
15. SWRAC - Move SMA data to file.

c. Offline Data Acquisition

1. DCOMP - Results/time of urine tests
2. KLOØ2 - Offline results 2, 3, 4 digits

3. KLOØ4 - Offline results choice of 2 items
4. KLOØ6 - Offline results choice of 3 items
5. KLOØ8 - Offline results choice of 4 items
6. KLO1Ø - Offline results choice of more than 4 items
7. KLO12 - Offline results miscellaneous quantitative with control
8. KLO14 - Offline results body fluid counts
9. KLO16 - Offline results semen analysis
10. KLO18 - Offline results routine urinalysis
11. KLO2Ø - Offline results urobilinogen or mucopolysaccharides
12. KLO22 - Offline results differential count and morphology
13. KLOM1 - Offline results PTDF
14. KLOM2 - Offline results blood gases
15. KLOM3 - Offline results gastric analysis
16. KLOM4 - Offline results 2, 3, 4 digits with control
17. KLOM6 - Offline results 2, 3, 4 digits with control - PT
18. KLORU - Update files for offline results
19. KLORV - Update files for offline results (differential count and morphology).

d. List Preparation

1. DADDC - "ADD" keyword master
2. DADDO - Add one specimen to a load list
3. DADMC - Add all available to a load list
4. DAUTC - Audit trail AutoAnalyzer/SMA activity
5. DCAP1 - Laboratory communication keyword control
6. DLCK3 - Load list master control
7. DLCK5 - Work list report
8. DLLAT - Load list build audit trail
9. DLLC1 - Load list builder
10. DLLR# - Find a load list entry using record number
11. DLLRD - Find a load list entry from scratch
12. DPLLC - Reprint load list master control
13. LLPRT - Print a load list.

e. Print Results

1. DLCK4 - Lab results master control
2. DRSC1 - CBC load list results
3. DRSC2 - SMA load list results
4. DRSC3 - Single channel load list results
5. DRSC4 - Two channel load list results
6. DRSCM - Print mark sense/SCI results.

f. Work Load Status

1. DLCK1 - Work load report.

g. Verify Results

1. DLCK6 - Verify lab results master control
2. DLVAT - Verify load list audit trail
3. DVLRC - Modify a load list result (VLR)
4. DVLRL - Verify a load list
5. RVIPS - Set/reset verify in process bit.

h. Specimen Condition Data

1. DSCIC - Specimen Condition Information (SCI) master control
2. DSCII - Post "SCI" condition in file.

4.2.7 Reports

a. Laboratory Management

1. Section Reports

(a) ADLOG - Process INHST, OPHST files, print daily log
(b) DACC# - Specimen retention report

2. Quality Control

(a) GQCC - Quality control master program
(b) GQCFM - Quality control data collection
(c) GQCP - Quality control report master program
(d) QCCPR - Quality control computation
(e) QCREP - Offline quality control
(f) QCRPT - Quality control format and print.

3. Statistics

(a) CSTAC - Statistics-demand reports
(b) MDSTC - Process TESTS file, update STATS file, print daily statistics report
(c) RLLSS - Load list standard/QC counter.

b. Inpatients

1. Cumulative

(a) ACPR1 - Scan ACPAT file, update INHST file
(b) ACPR2 - Sort inpatient history index file by ward/bed
(c) ACPR3 - Process INHST file, print cumulative reports.

2. Midday

(a) AIPRØ - Initialize VCORE COMMON for midday inpatient reports
(b) AIPR1 - Process ACPAT file, select inpatients, build and sort temporary index file for midday patient reports
(c) AIPR2 - Build temporary report record for one patient
(d) AIPR3 - Process report record, print midday report for one patient.

3. Admission Status

(a) BINPT - Alphabetic dump of inpatient file.

c. Outpatients

1. Daily

(a) AOPR1 - Scan ACPAT file, build OPHST file
(b) AOPR2 - Sort outpatient history index file by clinic/doctor
(c) AOPR3 - Process OPHST file, print outpatient reports.

d. Report Utilities

1. ANSWR - Convert a packed decimal number to 1443 code, insert decimal point, and suppress leading zeros
2. APATR - Select inpatient/outpatient reports for execution (based upon keyboard input)
3. APRNT - Print a line and allow overlapped processing
4. ARERR - Type an error message (for patient reports) and abort
5. ARRET - Type an error message (for patient reports) and return.

4.3 FILE SUMMARY

The seventeen files listed below are contained in the MILS data base. The information is organized to meet a variety of access and retrieval requirements. Variations in indexing and sequencing have been established to minimize file sorting and to be responsive to demands from laboratory, admissions and hospital wards.

a. Inpatient File—This file contains the name, social security number and other identifying information for each inpatient. The data is entered when a patient is admitted and is purged when the patient is discharged.
b. Active Patient File—This file contains data for those inpatients and outpatients for whom laboratory work has been requested. The data for each patient consists basically of indicators (i.e., test complete, specimen not collected, etc.) for the various tests that have been requested.
c. Active Patient Index File—This file is organized by accession number. Each entry points to the data in the Active Patient File for a given accession number.
d. Collection Schedule File—This file consists of one or more records for each hospital ward. Each record contains indicators as to whether specimens are to be drawn during ward round collection. For each bed assigned to a ward there is a pointer to the assigned patient's Inpatient File record.
e. Test File—This file is organized by test number and contains the status and results of all online and offline tests that have been requested for the patients whose names are contained in the Active Patient File.
f. Load List/Intermediate Results File—This file consists of load lists (i.e., list of accession numbers and related cup positions, etc.) for the various online instruments, and it contains the results of the online tests. The laboratory technician uses the data in this file to set-up his load list and to run his instrument. He then can obtain from this file the results for his instrument and either accept or modify the results (which will then be placed in the test file).
g. Inpatient History File—This file contains the results of all laboratory work performed during each patient's stay in the hospital.
h. Inpatient History Index File—This file is organized by Ward/Bed and points to data in the Inpatient History File.

i. Outpatient History File—This file contains the results of all outpatient laboratory work performed during the current day.
j. Statistics File—This file contains, for each unique test/procedure combination, counts of the numbers of requests and, by month, counts of the number of completions. For each unique procedure a count, by month, of the total number of standards and controls processed is maintained.
k. Quality Control File—This file contains statistical data by which the performance of various online instruments can be measured. It contains daily quality control specimen readings and statistical measurements (mean, standard deviation, etc.) by which the readings can be compared.
l. Test Descriptor Files—These files contain the many parameters associated with each of the laboratory tests (both online and offline). The parameters guide the collection of test samples, the testing of the samples, and the reporting of the test results.
m. Miscellaneous File—This file contains various tables of data needed by the MILS System programs.
n. Work File—This file provides a temporary disk work area for various MILS System programs.
o. T/P Message Buffer File—This file is used for buffering of messages that are destined for any of the 2740 communications terminals.
p. Checkpoint File—This file is used to save certain checkpoint information that must be restored (in core memory) at cold start time.
q. Card Image File—This file is used for the temporary storage of data cards.

Section 5. DESIGN CONCEPTS

5.1 DATA TRANSMISSION

Eight different types of instrumentation and eleven operator control boxes have been configured for online data acquisition. This extensive instrumentation configuration with the variations in instrument characteristics means several types of data transmission need to be accommodated. High level analog signals, low level analog signals, digital input voltage signals and digital input contact signals are required inputs to the central processor. Multiple process interrupt lines are installed to provide instantaneous response to the operator's desired actions. Digital output signals are incorporated to provide control light indications of system actions.

A special digital input feature allows multiplexing of digital inputs from several sources for transmission over the same lines. Economy in cabling is realized without degradation in response times.

To handle the total spectrum of laboratory information processing, several different peripheral devices are required. Data transmissions are accomplished through direct attachments to the central processor, as well as through use of overlapped data channel operations. Remote communications for data transmissions to and from ward terminals require start/stop teleprocessing techniques. Thus, common telephone cable can be used for the transmission media.

5.2 SYSTEM OPERATIONS

The design philosophy which has been followed is that the computer system should be an instrument used to accommodate the exploding information handling requirements. The system does not remove the responsibility for judgments regarding the integrity of laboratory results. Design concepts allow for system printouts of information prepared manually or by instrument. The ability to make changes or rerun as desired is an option available to the user prior to his verification which makes results available for reporting. Out-of-limits warnings are provided as operator alerts only. Acceptance or rejection remains an operator responsiblity. Hard copy is provided so all users may maintain individual records of their test activity.

System checks are provided for users where their action can update the information base. Checks are built in which require a positive response prior to taking final action.

A log of key events and the times of occurrence is printed by the system on the operator console. This provides a quick look status of instrumentation or communication devices. It further provides an historical record of system usage events.

A conversational mode of communication has been developed for users of keyboard terminals. The user depresses a key to get the attention of the computer. The computer acknowledges and the operator inputs a 3-character mnemonic describing the function he wishes to perform. The computer, in sequential steps, specifies the data to be entered. If an error is made the field is not accepted and the user is notified to reenter. A positive response lets the user know his function has been successfully entered.

Design considerations for the optical image ward terminal inputs permit repeated entry of the same field. The last entry is the one used and permits immediate overrides for mistakes. In order to provide operational flexibility, the sequence in which the parameters are entered is not fixed. Actions which can modify the information base require a second positive response from the user. Hard copy printouts provide the location records for actions taken.

The system is designed to support operations on a demand-response basis. Request for outputs represent status at that moment. Requests and/or directions may originate at any terminal station or from the CPU operator console. Interim or working documents (midday patient reports, for example) may be generated at any time and as frequently as desired. The MILS multiprogramming system provides an architecture consisting of five partitions, all of which may have operations in process simultaneously. Though the system is sequencing the internal operations on a priority basis, the appearance to the user is that the system is dedicated to his request. Further timesharing of batch type processing may be invoked through the operator console.

The flexibility of the MILS design does not dictate that a fixed set of procedures be performed in a specific sequence. The system can be utilized in the manner which best serves the needs of the installation. The procedures being used at William Beaumont General Hospital as of May 1, 1972 had the system in operation from midnight (0000) to eight P.M. (2000). This schedule was being followed Monday through Friday. The system was also in operation Saturday from 0730 - 1200. The schedule guidelines which were being followed by operational personnel are shown in the WBGH SOP (Attachment). Events need not take place at the specific times noted. Day to day variations in work loads and personnel resources cause the operational complexion to fluctuate.

5.3 LABORATORY SUPPORT

Accession numbers are assigned by the system for all requisitions entered. Numbers are assigned sequentially from 0000 to 9999. One character is added for laboratory section identification - H for hematology, U for urinalysis, etc. Duplicate accession numbers are prevented if some are still active when numbers are recycled. Accession numbers are retained in an active state until all associated work is complete. The design is structured so that multiple requests for one patient may be combined into a single accession number, depending on the procedures to be used. Multiple requests which cross section boundaries receive separate accessioning. The same holds true if different type of specimen are involved. Tests which are to be performed in the same section can be singly accessioned. Volumes of specimen, printed on laboratory labels, receive consideration of the procedures involved and the minimum amount is specified. Uncertainty of the volume required for multiple requests is removed. Certain tests require multiple specimens so provision is made for separate accession number assignment and individual label preparation. Some examples which are in use at WBGH are Oral Glucose Tolerance (up to seven blood and seven urine specimens), Other Glucose Tolerance (Six blood specimens), and a Hypertension battery (one blood specimen and one urine specimen).

Test categories are established for adult, infant, and child age groups. Additional categories are established to distinguish STAT from routine requests. All test attributes are defined in the system for each category. This feature permits procedures to be assigned based on age group and type of request. Volume of specimen and method of handling multiple requests is structured by age groups. Normal values are assigned according to the patient category.

Processing of each acquisition includes the assignment to an online procedure or a manual method. STAT requests can be assigned procedures different from the same test appearing on a routine request. Different procedures may be assigned depending on patient age category.

Test batteries are defined in the system to provide grouping of individual tests for diagnostic purposes and to coincide with instrumentation capabilities. Requests may be made for the battery, or individual elements in the battery may be requested. The laboratory may specify which elements requested individually should be scheduled as an instrumentation battery and which should be scheduled for a manual procedure. The laboratory has the facility to assign one element in a battery to the automated procedure and another element to the manual procedure. For example, a request for calcium could be scheduled for performance on the SMA while a request for total bilirubin could be scheduled manually, yet both are elements in the SMA battery. Only requested elements are included in reports returned to physicians.

When automating the information handling of a laboratory section it is necessary that all tests performed be handled, both by online instruments and by offline instruments, or manual methods be supported by the computer system. Partial test information support for a laboratory section requires dual procedures for processing requisitions, maintaining records of test status and results, and all other functions—negating many of the advantages of computer support. Incorporating all tests into the system extends the scope of results which need to be entered into the system. Eleven different mark sense sheets have been designed to handle the entry of multiple types of test results. Thus one piece of equipment is sufficient to handle all manual test result entries. Single marks on the sheet are translated into descriptive textual results on physicians' reports. Numeric answers are recorded by selecting the appropriate digit from 0-9. Text answers are selected from the list preprinted on the manual results sheet. All tests results can be accommodated using combinations of these mark sense features.

A variety of methods of presenting information on patient reports is necessary to transmit all results to the requestor. Numeric results or tests with alpha answers with less than five characters can be presented on a cumulative report horizontally across the sheet. Results with text results or text data intermixed with numeric data is arranged in a vertical format sequenced by date.

5.4 SYSTEM MODIFICATION

The system has been developed recognizing the dynamic nature of clinical laboratory services. The frequency of change in tests offered, instrumentation and methods dictates the need for the laboratory information system to be responsive to this changing environment. The approach taken was to establish test descriptor and procedure files within the data base. The processing modules reference the data base to obtain processing directions. These files contain the test attributes (name, abbreviation, normals, reporting formats, units, specimen volume, etc.), procedure assignments, and instrumentation set-up directions (position and designation of standards, quality controls, blanks, and specimens). Changes in laboratory services are recorded on punched cards and processed by file update programs. The next reference to the file by the system modules results in the latest version of the descriptive or procedure data being used.

Multiprogramming techniques have been selected to facilitate software changes or extensions. The programs which have been written were modularized to execute in the MPX core partitions. Several overlays may be required to complete a logical function, but this concept allows

additional programs to be added within the existing hardware configuration. Changes may be made in the program library while the system is online. The disk management program (DMP) executes in the background to replace a program with a newer version. The next execution of the program results in the latest version being used. No interruption in data acquisition, inquiry functions or other activities need occur while this system modification is being performed.

5.5 SYSTEM RELIABILITY

Fail soft techniques have been incorporated throughout the system design so reduced capability may result from failure of individual devices, but remaining system functions continue. Only three devices in the MILS configuration are critical; i.e., failure in any one of these will cause the system to be inoperable and back-up manual methods will have to be used in the laboratory. The critical devices are the CPU, the program residence file and the hospital information file.

Laboratory terminal and ward terminal design has been incorporated so any function may be performed on another similar device. The laboratory label printing function may be performed on another keyboard should the label printer malfunction. There is no equipment back-up for the line printer but information is retained on the file for printing at a subsequent time, when repair is accomplished. Meanwhile, the data (such as test starts and results) is available for inquiry via the terminals. A failure in an instrument, its interface or cable results in loss of online data acquisition for that device only. Tests which have been scheduled for performance on this instrument can be performed manually and entered using the offline results feature.

Any time a change in status or information occurs which effects subsequent processing, the status is checkpointed on system files. Should the system be taken offline for some period, the latest available status of operations will be reflected when online support is restored.

6.1 DEVELOPMENT

The Medical Instrumentation Linkage System (MILS) has been developed and implemented in an environment typical of the large U.S. Army hospitals. The laboratory at WBGH is representative of the wide variety of services provided and of the size of the patient base (inpatients and outpatients) requiring the services.

Project objectives included developing the system and placing it into operation. To accomplish these objectives, several transitions in the mode of operation were necessary during the project lifetime. The initial period was dedicated to development activities pointing toward the first major operational capability. The work in this period consisted of collecting requirements, designing the system, writing the programs and testing the software as it was completed. The computer in this period was dedicated to the development activities. When development and test were completed and the system was ready for operational support, a transition was made to a parallel mode of laboratory operation. During this period, laboratory personnel retained manual operations and also used the system. No dependence was placed on the system nor were system reports transmitted in this period. This period provided both a system shakedown and training of user personnel. Program discrepancies not detected during system testing became obvious during the parallel operation. The need for changes in initial design concepts also became obvious. These changes affected procedures, programming or combinations of the two.

The transition from a parallel operation to a dedicated computer operation was made when sufficient confidence had been established and personnel had developed a sufficient familiarity in using the system. At this point developments were initiated for the next major system capability. The development effort and the operational use diverged at this point, each concentrating on a different system. Separate periods of computer use needed to be established to support both objectives.

The operational system could not be ignored by the development team. Continuing maintenance and new requirements were fulfilled to satisfactorily support the continuing operation. The effect of these transitional steps was that, in addition to completing development, operational experience was gained as a capability became available. Phasing new developments into operational use meant that concepts were immediately tried under "field conditions." Requests for changes and additions which always surfaced as soon as a capability was put into actual use were accommodated. Experience has shown that no matter how lengthy the discussions preceding the writing of programs, final definition of requirements occurred only after a period of use. A realization of the nature of new developments on the part of the users was necessary for continuation of progress. Occurrence of program bugs or discovery of initial limitations had to be accepted. This constructive attitude was complemented by a responsiveness in making the program changes essential to successful utilization. Another advantage that accrued from the continuing implementation steps was that program bugs, detectable only during heavy system utilization by multiple users, were found and corrected. Certain software bugs are so subtle that the combination of operational events, which show the problem, may not occur until after several weeks of operational use.

The desire to implement newly developed features with modifications to those previously placed in operation imposed the requirement to control the content of the operational system. The operational system could not be modified to include features which were incomplete or which have not been thoroughly tested. The integrity of operations had to be maintained along with continued developments. A method of strict Version Control was put into practice after the laboratory became dependent on an operational system. The content of the next version to be released for laboratory support was mutually defined by programming and operations. A date would be selected for switchover to this next version of the system. A memorandum would be published prior to actual release in which all changes would be detailed, including any revisions in operational procedures. The programming staff would develop and test the new capabilities on a test system. When all development and testing was satisfactorily completed, the test system would be copied onto the operational system. The previous version of the operational system would be retained for a couple of weeks as insurance against unanticipated failure in the newly released system.

The programming staff participated in close surveillance for the first few days following release of new systems. If a catastrophic failure should have occurred, it would have happened during this period and all resources could have been applied immediately to quickly solve the problem and minimize the impact on laboratory operations.

Any time a problem was detected in the software, an evaluation was made to determine if the fix should be placed on the operational system immediately or whether the problem was such that the fix could wait until release of the next version. Those fixes which could be postponed until the next system release had the advantage of being exposed to more rigorous testing. However, certain fixes were made directly to the operational system in those cases where the malfunction was causing an impact on routine operations.

The maintenance of separate test and operational systems meant that a strict accounting of all software status had to be established and kept current.

The separation of development from operations meant that separate periods for use of the 1800 had to be observed by the two groups. The 1800 time-sharing features could be utilized for limited development activities during operational periods, e.g., the system could be used to perform program compilations and assemblies and utility functions in the background, while the laboratory was online. Execution of programs in a development state could not be permitted because of the risk of an untested program malfunctioning or destroying critical data. The system was dedicated for support of development work from 1630 to 2400. This resulted in the best utilization of the computer system. This meant the programming staff was required to work a less than ideal schedule - not an uncommon situation where development competes with production for available computer resources. This utilization of the system, shared by development and operational activities, was most instrumental in meeting difficult programming objectives with only minor impact on operations caused by nonavailability of the system.

Some attempts to establish an operational capability had to be aborted due to nonworkability in the laboratory sections. One attempt that failed was to process laboratory work from a single ward using the system. The extra effort imposed by the special case was excessive and could not be tolerated. An early version of the system was capable of supporting laboratory operations for a single day, but no retention capability existed to support carry-over work. The volume of laboratory work and late arriving requests to be performed the following day made the single day support not acceptable. Operational use had to await the development of the full capabilities in retaining all specimen and accession status from day to day. The system was required in the laboratory throughout the work day. It was not acceptable to be partially "on the computer" and partially "off." It was not feasible to switch back and forth between two different methods.

The magnitude of the transition from manual methods to use of the computer was much larger than had been anticipated. From the laboratory viewpoint this task was equivalent in size to the development efforts. In some instances this became a controlling factor in directing the subsequent developments. It was deemed advisable to develop additional features for the existing sections rather than to develop new subsystems and procedures for other sections. The biggest factor contributing to the difficulty in integrating the system was the ever-present demands on the laboratory. The workloads were extremely heavy throughout the integration period and there could be no relaxation in providing the daily hospital services. The staffing in the laboratory was less than optimum, so there was limited opportunity to learn the new procedures and integrate these into individual routines.

Though the transition period was difficult several advantages have accrued from implementing the system in an environment such as exists at WBGH. The broad range of services, the volume of activity and the frequency of changes have exercised nearly all of the concepts designed into the system. The need for improvements, which only became obvious after operational experience was gained, has been identified in nearly all areas due to the extensive use of the system. Those changes which were essential have been put in the system. Other changes or additions can be made to improve operations, but their absence does not restrict reliance on the system for routine laboratory support. The system has received a most rigorous exposure under actual conditions. The capacity to readily handle the loading during peak periods has been proven. Evaluation of the prototype may proceed with the unique advantage of an extensive operational experience base.

6.2 MILESTONES

Major project achievements are shown below. Included are development milestones, equipment deliveries, and incorporation of operational capabilities.

Begin Performance	Nov. 1, 1969
Complete Functional System Design	Dec. 15, 1969
Oral Briefing	Jan. 8, 1970
Design Review, WBGH	Jan. 23, 1970
Programming Specifications Complete	Feb. 6, 1970
Forms Design and Report Formats	Apr. 1, 1970
1800 System Delivered to WBGH	Apr. 27, 1970
Oral Briefing	Apr. 30, 1970
Computer Building Complete	May 1, 1970
Phase I Cabling Complete	May 1, 1970
Hardware Installation Complete	May 12, 1970
Control Boxes Delivered to WBGH	May 25, 1970
Install Lab Instrumentation - Phase I	Jun. 5, 1970
Oral Briefing	Jul. 9, 1970
Finalize Mark Sense Sheets and Label Formats	Aug. 22, 1970
Install Laboratory Terminals (1816's)	Aug. 31, 1970
Install 1053 Printer	Sep. 15, 1970
Install Mark Sense Page Reader	Sep. 24, 1970
Complete Development of Software (Ph. I)	Oct. 15, 1970
Complete Package Testing (Ph. I)	Nov. 1, 1970
Complete System Testing (Ph. I)	Dec. 1, 1970
Complete Audit (Acceptance) Testing (Ph. I)	Dec. 15, 1970
Oral Briefing - Phase I Demonstration	Dec. 17, 1970

Complete Design Specifications for Flame and Spectrophotofluorometer	Dec. 15, 1970
Mark Sense Sheets and Label Delivery	Jan. 8, 1971
Complete Design Specifications for Control Boxes for Differential Counter, Fibrometer, Coleman (includes interface and cable requirements)	Jan. 15, 1971
Initiate Parallel Operation in Laboratory	Feb. 15, 1971
Complete Instrumentation Functional Spec.	Mar. 1, 1971
Complete Instrumentation Software Design	Apr. 1, 1971
Complete Package Testing (Ph. II)	Apr. 1, 1971
Complete Functional Specifications for Ward Terminals	Apr. 7, 1971
Complete Audit (Acceptance) Testing (Ph. II)	Apr. 15, 1971
Briefing - Phase II Demonstration	May 14, 1971
Initiate Dedicated Online Operation	May 15, 1971
Deliver Four Control Boxes to WBGH	Jul. 15, 1971
Deliver Differential Counter to WBGH	Aug. 7, 1971
Package Testing Instrumentation Complete	Sep. 15, 1971
Complete 2760 Film Strip Design	Oct. 4, 1971
System Testing Instrumentation Complete	Oct. 15, 1971
Instali 1403 Printer	Oct. 28, 1971
Return 1443 Printer	Nov. 11, 1971
IL Flame, STAT Box Placed in Operation	Nov. 13, 1971
Three 2740/2760 Terminals Delivered	Nov. 16, 1971
BBL Fibrometer Placed in Operation	Dec. 10, 1971
Engineering Checkout Complete - 3 Terminals	Dec. 13, 1971
Package Testing Terminals Complete	Dec. 21, 1971
2760 Film Strips Delivery	Jan. 9, 1972
System Testing - Terminals Complete	Jan. 17, 1972
Keyboard Delivered for Differential Counter	Feb. 6, 1972
Terminal in Operation (Ward 7)	Feb. 7, 1972
Engineering Checkout Complete - 2 Terminals	Feb. 8, 1972
Differential Counter Placed in Operation	Feb. 12, 1972
Engineering Checkout Complete - 2 Terminals	Feb. 14, 1972
Statistics Package Completed and Placed in Operation	Mar. 1, 1972
Remaining Ward Terminals Placed in Operation	Mar. 15, 1972
Final Audit (Acceptance) Testing	Mar. 28, 1972
Final Oral Briefing	Mar. 30, 1972

6.3 DOCUMENTATION

Key documents produced during the project development are summarized below (not resubmitted with this report).

System Design Report	January 1970
Test Plan	June 1970
System Documentation Package	December 1970
Phase III System Specification	April 1971
First Phase of the MILS Project - the Laboratory Information System	May 1971

*System Documentation Package	May 1971
Cost Analysis Report	August 15, 1971
Development Status Reports were submitted monthly	
Memoranda describing extensions in the operational system were distributed as upgrades were released.	

6.4 EXPERIENCES

As implementation progressed toward complete reliance on the system, it became necessary to make changes in the equipment configuration and operational procedures. The "real-world" experience pointed out the need to deviate from the original plan to more effectively support the day to day operations.

6.4.1 1403 Printer

The original configuration included a 1443 line printer (250 lpm) for large volume patient and laboratory reports. A 2780 line printer was to be installed for remote printing of outpatient reports in a central location where these reports could be readily distributed.

As operational use increased it became desirable to print the cumulative report as the final daily patient report and to distribute it to the wards by 4:30 P.M. The daily log showing all status for the day (patients, locations, requests, results, accession numbers) was needed by the second shift personnel who began work at 4:30 P.M. It was desirable to delay report printing as long as practical in order to have the latest completions reflected in the report. In order to meet the objective of large print volumes compressed into short time spans the 1100 line per minute 1403 printer was installed. This enabled cumulative reports to be printed within the time constraints. The 2780 remote printer was deleted from the configuration and the print load projected for this device was assumed by the higher performance, local line printer. The net affect on the overall equipment configuration was a reduction in equipment costs.

6.4.2 STAT Entry Box

The original plans for the online instrumentation complex included the Coleman II. A control box was designed and built and the interface for data acquisition was established. Attempts to utilize the signal for result determination showed that an impedance-match problem existed between this instrument and the computer. Data transmitted was not sufficiently reliable for result determination. The problem could have been solved by adding electronics to provide immediate amplification. The delay which would have been introduced for procurement of additional components and the laboratory's desire to use the control box for other purposes resulted in the removal of this instrument from the online complex. The control box was converted to serve as a direct entry for digital results. New programs were written to support this function and the device was placed in operation in the Chemistry Laboratory. Later, when a separate STAT laboratory was set up in the WBGH laboratory, the device was moved to this location. This has eliminated mark sensing these results for computer processing. STAT's are transmitted directly to on-ward terminals when they have been completed. The direct entry of offline results and immediate transmission to the requesting service has significantly enhanced the laboratory's response.

*These documents are obsoleted by this report.

6.4.3 Digital Input Special Feature

The initial set of instruments and control boxes (SMA, AA's and Coulter Counter) was installed with a direct line for every digital input point (one line per bit). When the next set of online instruments (5) and control box requirements were defined, the requirement for a large number of cables and digital input points on the 1800 was reviewed. An alternate approach which uses an 1800 feature, Digital Input Special, was selected. This feature provides a multiplexing of the various devices over common lines into a common digital input group on the 1800. One group of ECO (Digital outputs) is used and the desired input group (16 bits) is selected under program control using an ECO bit pattern to uniquely define the input lines which will transmit on the next "READ." Economies have resulted in both the amount of cabling required and the number of digital input groups installed on the 1800. No degradation in user response results from this multiplexing of digital inputs.

6.4.4 Ward 26 Terminal

One of the project objectives was to install a single clinical terminal early in the operational period. A 1053 character printer was installed in Ward 26 to meet this objective. Programs were written to retrieve, format, and transmit patient reports on demand to this Ward 26 terminal. When the laboratory began logging all work (inpatients and outpatients) into the system, the local terminal did not have sufficient capacity to handle the peak load label preparation which occurred. The immediate solution to this situation was to "steal" the printer, which had been installed for patient reports, from Ward 26 and reassign it in the Lab Reception area as a dedicated label printer. This extra print capacity enabled the entry of all inpatient and outpatient test requisitions and the plan for phasing the system into dedicated operational use remained on target. In checking back to determine the source of the initial design oversight, two factors were discovered. Though the estimates of total laboratory volume were sufficiently accurate, there were significantly fewer collections than had been anticipated. This meant more inpatient work was generating non-collection label printing than had been anticipated. The other factor was the method of delivery of outpatient specimens. Frequently the clinics delivered large batches of specimens to the laboratory. These heavy workloads are generated for short bursts of time rather than being evenly distributed. Additional capacity was necessary during label preparation so as not to delay test performance at the laboratory work stations.

6.4.5 Admission and Discharge (A&D)

The original design specified installation of a terminal for entry of admission and discharge data in the admissions office. A keyboard terminal was installed for this purpose but the occurrence of operational problems resulted in transfer of this function to the laboratory reception area.

One recurring problem was caused by requests for inpatient work arriving at the laboratory in cases where no records for the patients had been established. Lab Receptionists would "admit" the patients so the requisition could be processed. Later, when the A&D clerk would attempt the admission the system would respond with notification that the patients were already in the system. This caused confusion for the A&D clerk as to the overall status of patient admissions.

At the time the terminal was located in the A&D Office, the system was online for only one shift. The system was supporting development activities on second shift and the third shift

operator had not yet been employed. Consequently, the system was not always available when A&D personnel resources could have been used to perform this function.

The online realtime entry of admission data from the Admission Office is the most desirable system approach for recording patient identification. The need for timely entry is especially reinforced when ward terminals are installed and nurses make bed assignments and lab requests using the terminal. These patient references on the ward can be accomplished only after the basic admission data is established in the system. Factors necessary for successful use of a terminal in the A&D Office include:

a. Sole responsibility in A&D for entry of admission and disposition data.
b. Sufficient personnel time must be available to perform the function.
c. The terminal must be online for extensive periods (at least 16 hours per day) on a regularly scheduled basis.

6.4.6 Terminal Configuration

The original design called for installations of 11 2740/2760 terminals in the nursing stations. This device was selected because it provided ease of use, hard copy transaction records, and could be expanded for other functions. The projection of film strip data, light pen type probe, a large number of possible inputs and program-controlled frame movement fulfilled the ease-of-use objective. Large numbers of nurses and doctors could thus learn the terminal operation with limited instruction and hands-on training.

Midway through the project, but before software had been developed, a new terminal was announced which was compatible with the 1800 System—the 3270. This new terminal offered the lastest technology, had all of the attractive features offered by the 2740/2760, had higher rates of data transmission, reduced overhead on the CPU, had improved performance through CRT and faster, silent printing, and was less expensive. This device was placed on order as soon as the product was announced. All efforts were made to procure this terminal in time to meet project schedule commitments. However, IBM production schedules could not be sufficiently improved to meet the project deadlines. It was not desirable to defer project schedules and plans were redirected to implement the 2740/2760s.

The final review of the configuration, considering the move to the new facility, resulted in selection and installation of seven ward terminals. These have been placed in operation and the U.S. Army objective of developing an experience base prior to moving into the new facility in July, 1972 is being realized.

Section 7. FUTURE DEVELOPMENTS

The nature of online EDP systems is that they do not remain static. Implementation of one feature generates the requirement for additional features. As operational experience is gained with existing features, ideas evolve where increased efficiency and productivity can result. Full value of the system is realized when progressive steps are continually taken toward accomplishment of these objectives. The MILS prototype can be profitably extended through increased data reduction and analysis, by extending the scope of present design to include additional applications and by making available additional operator options.

7.1 DATA REDUCTION AND ANALYSIS

Listed following are some areas where data reduction and analysis programming will provide added decision-making information for increased effectiveness. The basic data is presently available in either the online disk files or in the history files written on magnetic tape.

a. Analysis and exception reports of abnormal values
b. Comparison of today's results with previous results and exception reports where deviations are excessive
c. Summary of all lab work prepared on patient discharge
d. Statistical computations and summary of results by test and age groups
e. Analyses of services provided to the various requesting agencies.

7.2 ADDITIONAL APPLICATIONS

MILS has been designed and developed using modular concepts. The approach was taken to allow incorporation of new programs and to provide a facility to change existing ones at the installation.

The changes and extensions can be made on site by user personnel, following the modular concept for introduction of new programs. The incorporation of changes involves identifying the appropriate module(s), making the program changes, and using the DMP (Disk Management Program) to replace the old program with the new.

The computing capacity of the 1800 can be utilized to execute jobs which may be related to or completely independent of the laboratory. These programs would be initiated under operator control to execute in the background using available CPU time. These programs are assigned the lowest system priority so there is no interference with the online realtime functions. These programs may be placed in the program residence library, using the Disk Management Program to eliminate any handling of program decks and loading via a card reader.

There are many applications where the extension of EDP utilization will contribute to improved information handling. The clinical laboratory has made the most significant advancements in the application of EDP in their routine operations. Other professional services are being confronted with the same kind of situations, i.e., increasing workloads, decreases in clerical staff, more and more demands for information sooner and from multiple

sources, and technology advancements creating information at increasing rates. All of these factors contribute to the requirement for machine collection, organization, storage, retrieval and presentation of data to support the clinical decision making. Candidates for EDP use include, but are not necessarily limited to, ECG Analysis, Radiology, Patient Monitoring, Dietary, Patient Assessment, Outpatient scheduling and problem oriented patient records.

7.3 OPERATIONAL SUPPORT

Areas where operational improvements will result depend on the needs at specific installations. Some extensions have been determined as being desirable at WBGH. These can be added to the existing system as resources are available, and plans for operational implementation evolve. Adding the bacteriology and serology tests to the operational set will complete clinical laboratory automation at WBGH. The blood bank automation can be accomplished using a phased approach. A batch processing mode of operation using tape files would provide the blood bank with quick-look donor acceptability checks, emergency donor lists and statistical breakdowns including transfusion records by patient and service.

The online instrumentation complex can be augmented to include other instruments as they are installed and placed into operation. The most probable candidates at WBGH are a 4-channel electrolyte system and a 3-channel enzymes system. The interaction with A&D may be improved with the additional method of patient data entry through a punched card deck. Operational experience has shown that patient location on the lab result sheets and specific test requested noted on the specimen retention report will provide data for added convenience of the technicians. The ability to input all control box data through the keyboards will add a measure of reliability. A malfunction in the control box will, thus, not disable the online data acquisition. Selective reprints of collection schedules will enhance the recovery procedures when a line printer failure occurs during schedule preparation.

Programming modules have been developed, tested and integrated into a unified Laboratory Information System functioning in a realtime environment as a single operating unit. Several months of operational use have provided the thorough shakedown necessary to disclose required refinements and gain operational experience and confidence. The extensive operational use has validated MILS design concepts.

The value of the multiprogramming approach has been proven. The facility to add or update program modules within the existing architecture is used on repeated occasions. CPU processing of multiple tasks, simultaneously, is common during ordinary operations. Data Acquisition, Data Analysis, Test Requisition, Laboratory Communications and Ward Communication are frequently active all at the same time. To attain this degree of processing effectiveness, data organization that permits rapid storage and retrieval of any item must be included. Design of the MILS information base meets this criteria. The resulting throughputs meet the strict response standards necessary for user acceptance.

A design which permits changes in the test repertory, procedure assignments, reporting formats, and laboratory methods is both valuable and necessary. A system which supports all phases of the laboratory test cycle must be adaptive to the dynamics of the laboratory environment—this means frequent changes are routinely required and a flexible design must accommodate this mode of operation.

The system evaluation may be conducted in an operational setting under actual field conditions. Modifications may be implemented on a trial basis with decisions on final acceptability deferred until operational use is accomplished.

The anticipated efficiencies in clerical functions have been realized through automating the laboratory information. Improvements in operations have resulted from saved man hours which can now be applied to non-clerical responsibilities. Improvements in accounting and specimen control contribute to the laboratory effectiveness and improved service. Savings which can be directly measured in man hours due to elimination or reduction of these manual tasks are:

a. Sorting requisitions for ward rounds
b. Construction of work lists
c. Calculation of results
d. Recording results and maintenance of the log
e. Copy, sorting and filing data sheets
f. Manual sorting for specimen discard
g. Tabulating statistics
h. Production of quality control records
i. Telephone inquiries from requesting services.

Additional advantages are realized through system use. Although not as easily measured, they do contribute to the common mission of improved patient care:

a. Reduction in lost requisitions
b. Reduction in specimen redraws

c. Fewer requisitions repeated
d. Improved legibility resulting from machine printouts
e. Elimination of transcription errors
f. Standardization in specimen drawing, turntable set-ups, and result reporting
g. Possible excess of requests can be detected
h. Trends readily identifiable through history reports
i. Effect of treatment readily apparent
j. Lab results consolidated on one sheet
k. Faster interpretation of results is possible
l. Specimen disposition can be accomplished sooner
m. Status of lab work known at any time.

The scope of the system may be expanded to support additional applications—either laboratory related or pertaining to other hospital areas. EDP has historically been used in support of hospital administrative functions. The increase in demands for services, personnel shortages and instrumentation technology advancements produce the requirement for automated information handling in the laboratory. Solving the problem for the clinical laboratory is only an introductory step in support of Professional Services. The design concepts built into MILS have taken into consideration expansion into other Professional Service areas. Patient identification is maintained in a master file with "pointers" to the laboratory records. All laboratory files (patients, tests, specimens, quality control, etc.) are contained in the laboratory module. This data base may be expanded in modules to serve other professional needs (Patient History, Radiology, Nursing, Pharmacy, etc.). Pointers can be added for compatibility with this patient-oriented organization as other modules are introduced.

The architecture further provides for simultaneous processing of multiple operations. The information will, thus, be current and can be produced on demand for the hospital staff. Diagnostic decisions can be made using machine correlations of information from independent, yet clinically related, sources.

Appendix A

REFERENCE MANUALS

	Order Number	Title
1.	GA26-5921	IBM 1800 Bibliography
2.	GA24-3089	Teleprocessing and Data Collection Bibliography
3.	GA26-5920	IBM 1800 System Summary
4.	GA26-5919	IBM 1800 Data Acquisition and Control System Configuration
5.	GF20-8172	Bibliography of Data Processing Techniques
6.	GA26-5753	IBM 1800 Operating Procedures
7.	GA26-5918	IBM 1800 Functional Characteristics
8.	GA22-6866	IBM System 360 Component Description 2400 Series Magnetic Tape Units
9.	GA26-5756	IBM Disk Pack and Cartridge Handling Procedures
10.	GA26-5922	IBM 1800 Installation Manual—Physical Planning
11.	GC20-1630	Catalog of Programs for the IBM 1130 Computing System and IBM 1800 Data Acquisition and Control System
12.	GC26-3778	IBM 1130/1800 Assembler Language
13.	GC26-3775	IBM 1130/1800 Basic Fortran IV
14.	GC26-3724	IBM 1800 MPX Subroutine Library
15.	GC26-3718	IBM 1800 MPX Introduction
16.	GC26-3720	IBM 1800 MPX Programmers Guide
17.	GC26-3725	IBM 1800 MPX Operating Procedures
18.	GC26-3727	IBM 1800 MPX Error Messages and Recovery Procedures
19.	GY26-3726	IBM 1800 MPX Program Logic Manual
20.	GC22-6820	IBM System 360 Installation Manual—Physical Planning
21.	GA24-3488	Form Design Reference Guide for Printers
22.	GA26-5988	IBM System 360 Component Descriptions—DASD for 2841
23.	GA24-3403	IBM 2740 Communication Terminals Models 1 and 2 Component Description
24.	GA27-3001	IBM 2740/2741 Communications Terminal—Operators Guide

	Order Number	Title
25.	GA24-3435	Planning and Installation of a Data Communications System Using IBM Line Adapters
26.	GA27-3011	IBM 2760 Optical Image Unit Component Description
27.	GA24-3073	IBM 1403 Printer Component Description
28.	C20-1668	Data Communications Primer
29.	C30-2007	IBM System 360 Introduction to Teleprocessing
30.	GA24-3090	IBM Teleprocessing System Summary
31.	L26-2112	Start/Stop Teleprocessing Adapter General Information Manual RPQ C08763
32.	GX26-3573	IBM 1800 Data Acquisition and Control System—Physical Planning Template
33.	GA27-3006	IBM Remote Multiplexers and Communications Terminals Installation Manual—Physical Planning
34.	GX26-3780	IBM 1130/1800 Assembler Language Statements Summary
35.	GX26-5624	IBM 1800 Reference Summary System Reference Data
36.	GX26-1594	IBM 1800 Reference Summary MPX Control Statements

Appendix B

MILS OPERATING SCHEDULE

Time	Tuesday - Friday Procedure
0000-0100	Dump system files (2311) on backup tape
	Gather backlog, enter requisitions, and results if work complete
0100-0200	Do file maintenance for previous day Reinitialize system for current day Start 2740/2760 terminals Print inpatient roster Run instrumentation diagnostics
0200	Initiate log-in of current laboratory work as it arrives Obtain requests for ward round collection Transcribe and enter ward round requests
0530	Print labels for ward round collectors and set out labels for collection team Print specimen retention reports for use during collection verification
0600	Obtain current admission data and enter new admissions Print updated alpha inpatient roster
0645	Lab technologists begin system use—instruments, lists, result entry, etc. This continues throughout the day
0715	Print first midday reports for selected wards (e.g., ICU)
0730	Verify ward round collection as collectors return
0830	Assign "cut-off" number for Chemistry Section when all collectors have returned (procedural only)
	Obtain and save workload reports—all sections
0800	Chief, MILS reviews previous day outpatients reports, files for distribution
0900	Obtain quality control results from previous day for offline tests Update quality control card file for offline tests Print offline Quality Control Report Print online Quality Control Report Distribute Q.C. reports to sections
1200	Obtain and save workload reports for all sections Print midday inpatient reports (provided morning SMA run is complete) Chief, Clinical Path reviews reports and has them distributed to wards

Time	Tuesday - Friday Procedure
1230	Print outpatient log
1300	Enter patient discharges
1400	Midday reports, selected wards (medicine)
1430	Print outpatient log
1500	Print midday reports Pathologist review and distribute
1530	Generate labels for Cardiology Clinic outpatients to be seen the following morning (names of patients supplied by Cardiology Clinic)
	Get count of day's requisitions and file request slips
1600-1900	Log in laboratory requests
1900	Print Cumulative Inpatient Reports, Outpatient Reports, Daily Log, Specimen Retention, Daily Lab Summary
2000-2400	Laboratory is offline—System is available for development purposes

Procedure for Monday

Cold start as previous day
Obtain and save workload reports for all sections
Build final inpatient and outpatient reports
Perform file maintenance
Obtain and save workload reports
Stop system
Cold start as correct day
(Continue from point of starting 2740/2760 terminals)

Procedure for Weekend

Cold start as previous Friday
Obtain and save workload reports for all sections
Build and print non-final outpatient reports.
(These will be reviewed and distributed the following Monday)
Build final outpatient reports
Print outpatient logs and specimen retention reports and distribute to lab sections
Perform file maintenance
Obtain and save workload reports
Stop system
Cold start as Saturday

Time	Procedure for Weekend
	Log in routine requests received during Saturday
	Build final inpatient and outpatient reports
	Print inpatient and outpatient logs and distribute to lab sections
	Print final inpatient reports if necessary (contingent upon degree of completeness of reports printed on previous Friday).
	Review and file for distribution if reports are printed
	Perform file maintenance
	Stop system
	Cold start as Sunday
	Log in routine requests received during Sunday
	Stop system

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