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ABSTRACT

Project IMPACT (Instructional Model Prototypes Attainable in Computerized Training) is a comprehensive advanced development project designed to produce an effective and economical computer-administered instruction (CAI) system for the Army. The computer hardware and software capabilities of the prototype system are described. The components of the computer hardware/software subsystem are discussed in terms of the four main activities they support: administering instruction to students; implementing courses into CAI format; evaluating students, courses, and instructional decision models; and performing administrative functions in a school. Specific courses of instruction, research programs, or instructional strategies are not discussed. Rather, emphasis is placed on the capabilities and overall structure of the system. (Author)

Technical Report 70-22

Project IMPACT—Computer-Administered Instruction: Description of the Hardware/Software Subsystem

by

The IMPACT Staff

HumRRO Division No. 1 (System Operations)

December 1970

Prepared for:

Office, Chief of Research and Development Department of the Army

Contract DAHC 19-70-C-0012

Approved for public release, distribution unlimited.

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HUMAN RESOURCES RESEARCH ORGANIZATION

Technical Report 70-22
Work Unit IMPACT

The Human Resources Research Organization (HumRRO) is a nonprofit corporation established in 1969 to conduct research in the field of training and education. It is a continuation of The George Washington University Human Resources Research Office. HumRRO's general purpose is to improve human performance, particularly in organizational settings, through behavioral and social science research, development, and consultation. HumRRO's mission in work performed under contract with the Department of the Army is to conduct research in the fields of training, motivation, and leadership.

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FOREWORD

This report summarizes the concepts, approach, and developmental activity in establishing the first generation hardware/software subsystem (HSSS) of Work Unit IMPACT, Prototypes of Computerized Training for Army Personnel. IMPACT is an advanced development project undertaken by the Human Resources Research Organization, designed to provide the Army with a system for computer-administered instruction (CAI).

The National Science Foundation is also sponsoring HumRRO research on Instructional Decision Models (IDMs), with additional support provided by the James McKeen Cattell Fund. This document is also intended to serve as the first report to the Foundation on the progress of the hardware/software subsystem toward implementing the initial IDM within the HumRRO CAI environment.

The research is being conducted at HumRRO Division No. 1 (System Operations), Alexandria, Virginia, where Dr. J. Daniel Lyons is Director. Dr. Robert J. Seidel is the Program Director.

Technical contributions to the development of the HSSS were made by Mr. Jean A. Garneau, Mr. Leslie W. Willis, Mrs. Doris Shuford, Mr. John Stelzer, Mrs. Beverly Hunter, Dr. Felix Kopstein, Dr. Ronald Swallow, Miss Lala J. Curry, Mrs. Judith G. Compton, Dr. Harold G. Hunter, Mr. George R. Sedberry, and Dr. Robert J. Seidel. Mrs. Hunter and Mr. Martin L. Rubin contributed to the organization and writing of the report.

The IMPACT project and the IDM research program follow on earlier HumRRO work in the same general area under Work Unit METHOD, Research for Programed Instruction in Military Training, and Exploratory Research 42, Organization of Instruction. Principal publications under these research efforts include: *Project IMPACT: Computer-Administered Instruction Concepts and Initial Development*, by Robert J. Seidel and the IMPACT Staff, HumRRO Technical Report 69-3, March 1969; *The Computer as Adaptive Instructional Decision Maker*, by Felix F. Kopstein and Robert J. Seidel, HumRRO Professional Paper 1-70, January 1970; *Project IMPACT: Description of Learning and Prescription for Instruction*, by Robert J. Seidel, *et al.*, HumRRO Professional Paper 22-69, June 1969; *The Application of Theoretical Factors in Teaching Problem Solving by Programed Instruction*, by Robert J. Seidel and Harold G. Hunter, HumRRO Technical Report 68-4, April 1968; *Programed Learning: Prologue to Instruction*, by Robert J. Seidel, HumRRO Professional Paper 17-67, April 1967; and *Computer-Administered Instruction Versus Traditionally Administered Instruction: Economics*, by Felix F. Kopstein and Robert J. Seidel, HumRRO Professional Paper 31-67, June 1967.

Identification of products is for research documentation purposes only, and does not constitute an official endorsement by HumRRO, the Department of the Army, The National Science Foundation, or the James McKeen Cattell Fund.

HumRRO research for the Department of the Army is conducted under Contract DAHC 19-70-C-0012. Computer-Administered Instruction research is conducted under Army Project 2Q063101D734. The IDM research being conducted under National Science Foundation sponsorship is funded under Grant GJ-774, Research on Instructional Decision Models, with additional funds from the James McKeen Cattell Fund.

Meredith P. Crawford
President
Human Resources Research Organization

BACKGROUND

In order to cope with rapidly changing conditions and at the same time increase its posture of readiness, the U.S. Army may have to change some of its priorities, especially in the area of training its personnel, upon whom increasing demands will be made. With financial resources shrinking, less new equipment being developed, and a smaller, all-volunteer force in prospect, personnel will increasingly be recognized as the Army's most vital resource, and training will assume a more dominant position.

Among the problems faced by those responsible for training in the Army are broad student differences, decreasing numbers of skilled instructors, personnel fluctuations, and the need for flexibility and continual updating of courses. Computer-Administered Instruction (CAI) is expected to make a major contribution toward providing training adequate to the task of dealing with these problems.

The objective of Project IMPACT is to evolve a series of prototype systems of Computer-Administered Instruction in order to produce a prototype operational CAI system that is effective, efficient, and cost beneficial for use in Army training. A total CAI system consists of four kinds of components:

(1) The computer and its associated hardware devices
(2) The computer software
(3) Courses of instruction
(4) Instructional decision models (IDM)

The computer hardware and software, taken together, comprise a subsystem that is the subject of this report.

Objectives

The objectives for the IMPACT CAI hardware/software subsystem are, first, to provide, within the development time and cost constraints, a generalized and flexible tool for research and development of CAI instructional decision models and courses of instruction; second, and equally important, to provide computer hardware and software that is operationally efficient and economical for large-scale Army CAI use.

The hardware/software subsystem is designed to provide the flexibility needed to develop courses in a variety of subjects of instruction, according to a wide range of instructional strategies, for a spectrum of Army student populations, within a framework of research development and experimentation.

The hardware/software prototypes must therefore provide a balanced capability that will satisfy the requirements for instructional development (needed to develop the IDM and course prototypes), and the requirements for efficient large-scale Army operations.

Approach

The approach taken toward the development of the hardware/software subsystem (HSSS) reflects a compromise between immediate and longer-range requirements. Off-the-shelf hardware and software components were used wherever possible, and tailored or modified to provide greater research flexibility and greater potential for operational efficiency and economy.

The approach used to achieve the balance between development and operational requirements was to design the tools needed for research, and to implement these tools and capabilities in computer hardware and software technology that can be expanded and refined to provide operational efficiency.

Subsystem Description

The hardware/software subsystem supports four main activities in a CAI environment. These are:

(1) Presenting instruction to students.

(2) Implementing courses into CAI format

(3) Evaluating students, courses, and instructional decision model.

(4) Performing administrative functions in a school.

In support of these activities, the subsystem includes the following components:

(1) A general-purpose digital computer, usually classed as a medium-scale, third-generation computer (IBM 360 Model 40). This computer was selected because it has the general characteristics of, and is compatible with, larger-scale computers that would be required for operational CAI for the Army.

(2) Twelve cathode ray tube (CRT) terminals for student-computer communication. A commercially available CRT device (Sanders 720) was selected for its wide range of capabilities from a research standpoint and for its technological similarity to a family of terminal devices that are predicted to be the most economical for large-scale use in Army training.

(3) Experimental devices for student-computer communication, including a computer-controlled film projector with addressable frames; a tablet for handprinted input to the computer; and a voice frequency analyzer which enables a student to speak to the computer in single words.

(4) Direct access storage (IBM 2314 disk) for storing course material, student performance records, and IDM. These storage devices make it possible to have several thousand hours of instruction available online at a time, a necessity in an operational Army school environment.

(5) IMPACT-Coursewriter, a computer software package that controls the operation of the hardware to perform CAI functions. A CAI software package already developed by IBM (Coursewriter III) was modified to provide greater capability for collecting data, and to interface with remote CRT terminals that would be needed in an operational Army setting.

(6) Zeus, a computer software monitor that makes it possible to operate multiple CRT terminals from locations remote from the central computer.

(7) EDITOR (Entry on Disk of Instructional Text for Online Retrieval), a set of computer commands that enable authors to create, modify, and retrieve instructional materials on the CRT.

(8) DIRECTOR, a software supervisor that retrieves course content from disk and transmits it to individual students at the appropriate time. DIRECTOR is the interface between course programs and IDM (which decide *what* instruction a student needs next) and the student.

(9) IMPACT Data Evaluation System (IDES), a software package that manages the data collected, stored, and processed for evaluation of students, courses, and IDM.

(10) File Activity Control System (FACS), a software package that assists authors in preparing content for CAI courses.

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Part 1

INTRODUCTION

THE ARMY AND COMPUTER-ADMINISTERED INSTRUCTION

In order to cope with rapidly changing conditions within its organization and at the same time increase its posture of readiness, the U.S. Army of tomorrow will have to change some of today's priorities. Greater emphasis will especially have to be placed on the training of its personnel, upon whom increasing demands will be made.

With shrinking financial resources, less equipment development, and a smaller, all-volunteer force in prospect, the Army will increasingly recognize personnel as its most vital resource, and training will assume a more dominant position than it does today.

Army training will have to be adequate to the task of dealing with widespread differences among students, especially in the event of a mobilization buildup and the resulting mass training requirements. To those responsible for Army training, individualized training is the key to meeting these requirements. With fewer skilled instructors available, the fluctuation in personnel, and the requirements for flexibility and continual updating of formal and on-the-job courses, Computer-Administered Instruction (CAI) with its unique capabilities is expected to assume a major role in providing the training required for the Army's readiness goals.

The use of general purpose digital computers for instruction is a relatively recent development in educational technology. "Computer Assisted Instruction" as it is generally called holds vast promise for providing a more effective, efficient, and economical instructional system than traditional instructional methods and systems. The promise lies in the potential of the computer for adapting instruction to the momentary needs and capabilities of the individual student, for use at his own pace.

The U.S. Continental Army Command (CONARC), which is responsible for training in the Army's school system, has established a long-range plan for automatic data processing (ADP) that includes the use of the computer's capability for training. The plan contains CONARC's philosophy concerning CAI:

> The philosophy of CONARC concerning Computer Assisted Instruction remains essentially the same as the philosophy presented in the briefing for the Assistant Secretary of Defense for Education in December 1967. It stated that management controls at all levels of command must insure that the integration of CAI into the Army school system is free of duplication of effort, is economical in the use of resources, and is progressively leading to the accomplishments of the Army objective which is to provide computer operational capability for the conduct of instruction for all Army Schools. To guarantee strict adherence to this philosophy, USCONARC exercises a progressive developmental policy which encourages projects for investigations in discrete applications of the computer in support of a training function to insure that the established feasibility of this technology is strengthened and refined. It has been ascertained that further investigation should be undertaken in several CAI modes, notably drill and practice, simulation, and student dialogue. On this basis, initial projects for each of these modes are being conducted at separate USCONARC schools.

Additionally, all school faculties must be trained for identification and development of CAI applications to assure attainment of the objectives listed above.[1]

To support these objectives, Project IMPACT (Prototypes of Computerized Training for Army Personnel) has been established as an integrated, multidisciplinary CAI effort. The objective of the effort is to evolve, through cyclical development and evaluation, an effective, efficient, and economical Computer-Administered Instructional system. The term "Computer-*Administered*" is used because the computer in this system houses the controlling and adaptive instructional decision model (IDM).

Problem areas addressed include computer system capabilities, CAI language needs and CAI potential, and, of prime importance, the meaning of instructional strategies and their relationships to learning processes. Project IMPACT is unique in that it considers the total instructional system. The problem for any instructional agent (human or machine) is to take optimal action in line with an overall "best" strategy for transmitting to the student information uniquely relevant to him. If proficiency criteria are to be attained effectively and efficiently, recurrent decisions concerning these instructional actions must be made relative to (a) the subject matter being taught, (b) the specific student, (c) the momentary circumstances, and (d) the available options (communication channels).

The potential of CAI will be realized only with a systematic, persistent, and iterative scientific effort leading to a synthesis of principles into a potent model of the instructional decision process. With this realization the new system of instruction can be molded into a cost/effective undertaking.

This total instructional system is considered in Project IMPACT over four phased development cycles. The heart of this total system CAI effort is the iterative development and testing of instructional decision models (IDMs). During the four cycles of development and testing, the components of the effort (hardware, software, subject matter, and IDM) are to be revised and updated. The first two cycles comprise the development and the evaluation of the "breadboard" (preliminary) CAI system. To be undertaken in cycles three and four are the synthesis and implementation of the refined components into a prototype operational CAI system—what IMPACT will ultimately provide to the Army.

This advanced development effort will supply the Army with its own capability for developing sound, effective CAI materials. These generalized logic subprograms will be designed and documented for use by technically unsophisticated personnel such as instructors, lesson designers, and subject-matter experts so that they will be able to modify the course for their particular purposes. Through the development of a useful family of instructional decision models the programs of instruction will be adaptable to the moment-by-moment capabilities of the individual trainee and the content made relevant to his specific job requirements.

The products will also include design requirements for hardware configuration for operationally implementable Army CAI. In the software area, computer language will be developed to facilitate interaction between author and computer, trainee and computer, and administrator and computer. User documentation will be provided to simplify the implementation of these products.

Since the approach of Project IMPACT is a total systems view of CAI, all components of the system, including hardware, computer software, instructional content, instructional strategies, and learning principles are included in the development of the prototype and in the research studies conducted. Project IMPACT, which began in FY 1968, is described in detail in *Project IMPACT: Computer Administered Instruction*

[1] Headquarters, U.S. Continental Army Command, Director of Management Information Systems. "USCONARC Long Range ADPS Master Plan (Schools)", 27 December 1968. Part III, "Narrative".

Concepts and Initial Development (1). In this report, the present IMPACT hardware/software subsystem is referred to as IMPACT-A HSSS. IMPACT-A HSSS is a "first-generation" prototype, not intended for implementation in Army schools. On the basis of experience with IMPACT-A, specifications are being prepared for an operational CAI HSSS. This next generation is referred to here as IMPACT-B HSSS. When the term "system" is used, it refers to the total CAI system including HSSS plus IDM, course of instruction, instructional strategies, and students. A Glossary of terms used in this report is provided in Appendix A.

PURPOSE OF THIS DOCUMENT

This document provides an introduction to the capabilities of the IMPACT-A HSSS. It does *not* describe specific courses of instruction, IDM, research programs, or instructional strategies that are a part of the total system development at Project IMPACT.

This report is the first in a series designed to provide introductory information to Army training experts, prospective managers of CAI installations, and instructional system planners. It should help to answer such questions as:

(1) What tools does the HSSS provide for administering instruction?
(2) What instructional environment is provided to the student?
(3) What tools does the HSSS provide for instructional programmers?
(4) What capabilities are provided for evaluating the CAI system and the courses?
(5) What are the major constraints in the system? (For example, dependence on specific hardware or subject matter.)
(6) What hardware and software resources are required to implement a given component?

Other reports, now in preparation, will describe the hardware and software subsystem in more detail, including course implementation capabilities, facilities for course administration, and evaluation.

SALIENT FEATURES OF THE HARDWARE/SOFTWARE SUBSYSTEM

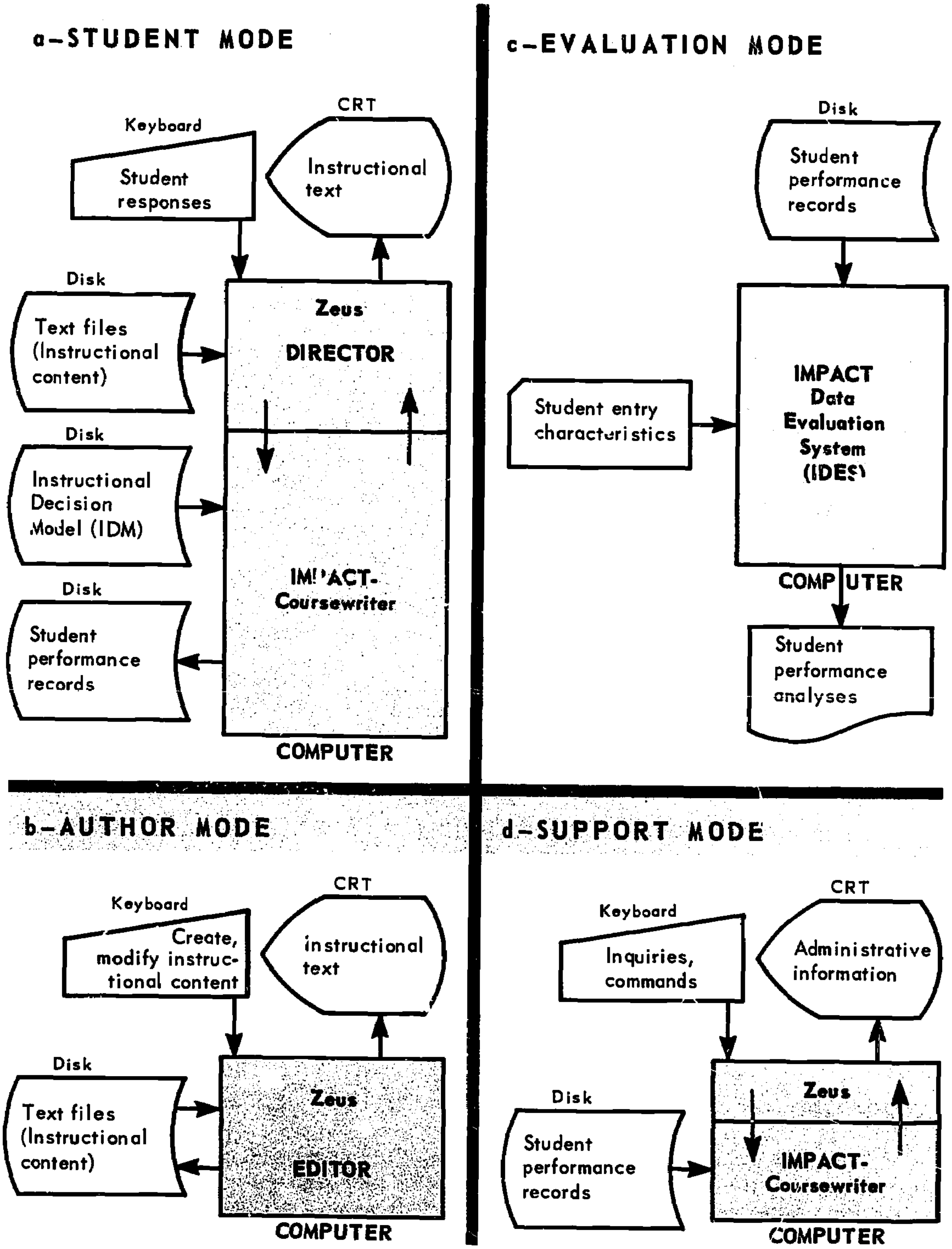
The HSSS provides a generalized capability for administering, developing, and evaluating individualized courses of instruction and tests. In the IMPACT CAI system, the computer acts as an instructor or tutor in that it interacts with students individually, presents material to the student as needed, and evaluates the student's progress in achieving course objectives. It is thus a "tutorial" CAI system, as distinguished from other uses of computers in training, such as in simulations or games, or as a problem-solving tool.

OPERATING MODES

The HSSS is designed to operate in four modes, corresponding to different activities performed in a CAI center, and illustrated by the four segments of Figure 1. The HSSS operates in these modes either separately or concurrently.

In Figure 1a the components that operate in *Student Mode* are shown. This is the mode in which instruction is being administered to students.

Overview of IMPACT CAI System Components and Operating Modes



NOTE: See Appendix B for explanation of flowcharting symbols.

Figure 1

The system components in operation in *Author Mode* are shown in Figure 1b. In this mode, the instructional content is prepared by the authors who then have it stored in the text files.

The components utilized in the *Evaluation Mode*, in which educational researchers evaluate instruction and IDM, are illustrated in Figure 1c.

In Figure 1d the components used in the *Support Mode* are shown. In this operating mode, student performance records are queried by school personnel for administrative information.

PRIMARY COMPONENTS

Hardware

(1) The central computer, an IBM 360 Model 40 (moderate-size, third-generation computer).[2]

(2) Student stations for input and output to the computer, including cathode ray tube (CRT) and keyboard, a film projector, hard-copy devices, and experimental hand-printed and voice-input devices.

(3) Direct access storage (IBM 2314 disk) for course material, student performance records, and instructional logic.

(4) Equipment required to support communications between computer and remote student stations.

Software

(1) Zeus, a computer software supervisor that supports CRT terminals at locations remote from the central computer.

(2) EDITOR (Entry on Disk of Instructional Text for Online Retrieval), a simple to use yet powerful set of commands that enable course authors to create and modify course materials on the CRT and have them stored on disk (text files) at the central computer.

(3) DIRECTOR, a software supervisor that retrieves the appropriate course content for an individual student and transmits it to his student station. DIRECTOR is the interface between course programs and IDM (which determines what instruction to present next), the course materials, and the student.

(4) IMPACT-Coursewriter, a generalized CAI software package that includes:
- (a) IBM Coursewriter III author language.
- (b) Coursewriter III processor augmented with functions required for IMPACT research.
- (c) An input-output control program expanded by IMPACT to support remote CRT terminals.

(5) IMPACT Data Evaluation System (IDES), a data management package used to structure and retrieve student and course performance data.

(6) File Activity Control System (FACS), a software package that assists authors in preparing the content of CAI courses.

[2] Identification of products is for research documentation purposes only and does not constitute an official endorsement by HumRRO, the Department of the Army, the National Science Foundation, or the James McKeen Cattell Fund.

Part 2

IMPACT-A HSSS CAPABILITIES FOR ADMINISTERING INSTRUCTION

When the computer is administering instruction to students it is said to be in "student mode" (Figure 1a). This section of the report describes student mode operation and capabilities.

OPERATION OF THE SYSTEM IN STUDENT MODE

The major components of the system that operate in student mode are shown in Figure 2. Circled numbers in the discussion that follows correspond to the numbers on the figure.

HSSS Components Involved in Administering Instruction

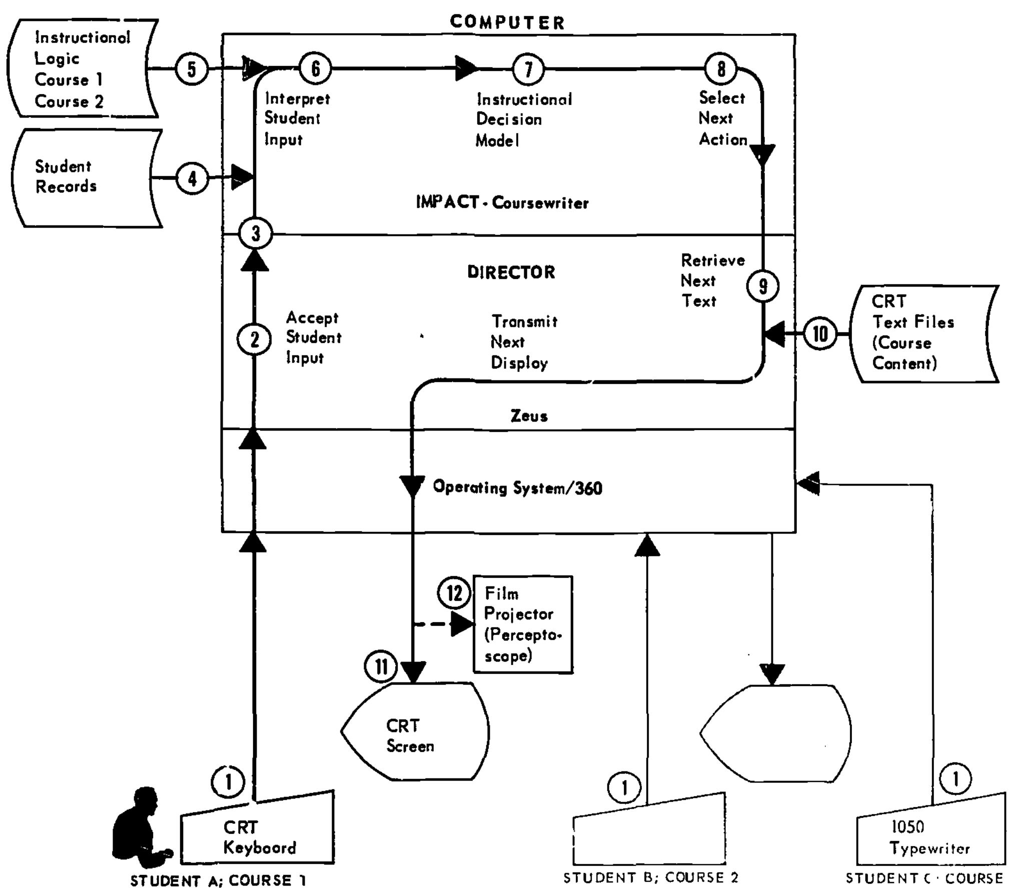


Figure 2

The student keys his input to the computer (e.g., an answer to a question or a request for assistance) through either a CRT keyboard or the 1050 typewriter keyboard (1). (This discussion will refer to the use of the CRT only.)

The student input is received in the computer by *Zeus* (2). Zeus signals the IMPACT-Coursewriter (3) processor that the message has been received and is ready to be processed.

IMPACT-Coursewriter determines *which* student has transmitted this response, and what stage he has reached in the course (from the records at (4)). IMPACT-Coursewriter processor then obtains the appropriate segment of course logic instructions from the course program (5). IMPACT-Coursewriter executes instructions in the course program which tell how to interpret the student's input (6), thereby providing the student response portion for the IDM decision on what action is to be taken next (7). The IDM decision is transmitted to the course program, which selects the next course program instruction to be executed (8).

IMPACT-Coursewriter output control transmits this instruction to DIRECTOR (9). DIRECTOR finds and retrieves the appropriate material from the text files (10). DIRECTOR transmits that display, through Zeus and the IBM 360 Operating System, to the student's CRT (11). The frames of a film to be presented along with the CRT display are computer controlled. A special electronic device (not shown in Figure 2) interprets the computer commands and activates the film projector (Perceptoscope) (12) (2). The student reads the displays and makes the response called for by the instruction (1). As shown in Figure 2, many students may be instructed simultaneously, from one or many courses.

CAPABILITIES FOR INSTRUCTIONAL OUTPUT

The HSSS output capabilities required for a given course vary depending on the subject matter being taught, the skills of the students, and the instructional strategies being used. An objective of Project IMPACT is to provide a range of output capabilities in the HSSS, in order to allow for teaching a variety of subject matter and to provide a broad base for CAI research.

The output capabilities are a combined function of hardware devices and the computer software. The three basic output devices presently used are a CRT display, teletypewriters, and a film/slide projector. The major portion of the software is in Zeus and DIRECTOR.

HARDWARE DEVICES

CRT Display

The CRT used for IMPACT-A HSSS is the Sanders 720, which has a wide range of capabilities compared to other commercially available CRTs. These capabilities are being evaluated as they are used, so that the IMPACT-B CRT can be specifically tailored to CAI requirements. The Sanders 720 can be located at distances remote from the central computer via telecommunication lines (given the necessary software). It can project up to 1,024 alphabetic, numeric, and special characters on a page. These characters may be distributed over 2,080 screen positions.

The primary asset of this CRT for instruction is its large repertoire of formatting capabilities. The display screen can be divided into variable length logical "blocks" (Figure 3). These blocks can be used for various instructional output purposes, such as explanation, question, response, feedback, or remediation. A CRT display is illustrated in

Schematic of CRT Block Structure (Example)

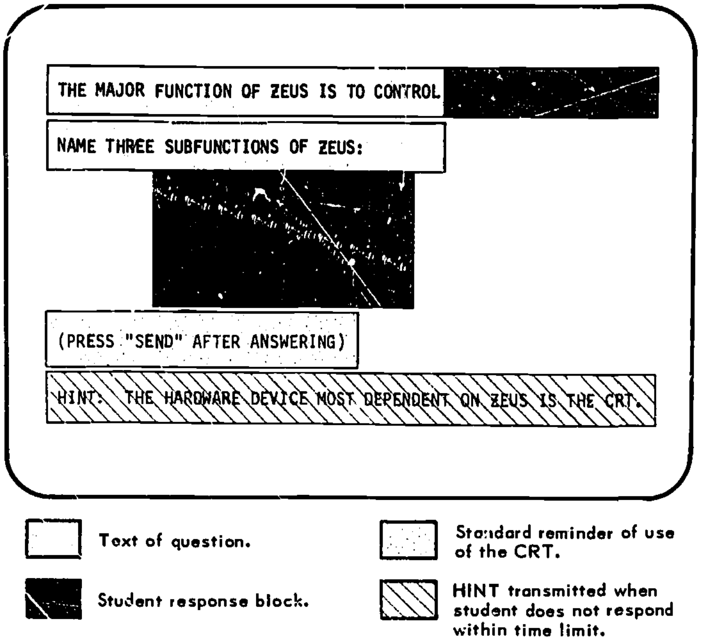


Figure 3

Figure 4, and Figure 5 shows the same text display, with a feedback message that has been added to it by DIRECTOR. This is accomplished without retransmitting the information from the prior display. (Greater detail on the Sanders 720 is found in Part 6 of this report.)

Hard-Copy Devices

Two types of hard-copy devices, with different purposes, may be used for output to students. One is a teletype device used to copy the display or "page" that is on the CRT screen. This device is under the control of the CRT keyboard and may not receive messages directly from the computer. This capability may be used by a student to get a copy of a homework assignment or some other material for use "offline".

The other hard-copy device is the IBM 1050 typewrtier terminal.[3] Output on this device is under computer control. The typewriter receives text from the computer and the student responds through the 1050 keyboard. Formatting material for the IBM 1050 is substantially different than with the CRT. Material prepared for presentation on the 1050 can be used, essentially unchanged, on the CRT. However, material prepared for CRT cannot be presented on the 1050.

[3] The 1050 terminal configuration was deleted from the system, for budgetary reasons, as of July 1970. However, their use in the system is described.

CRT Display With Question for Student

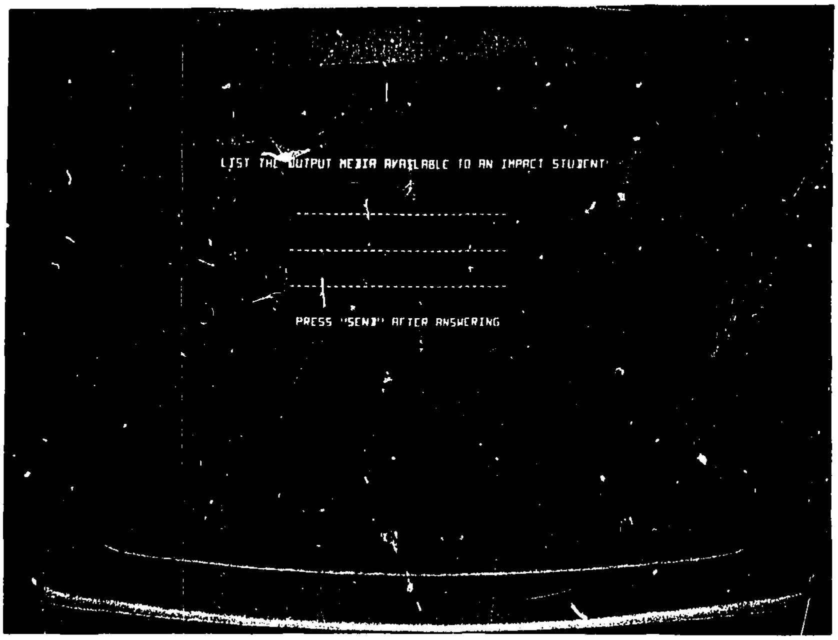


Figure 4

CRT Display With Student Response and Feedback After Student Response

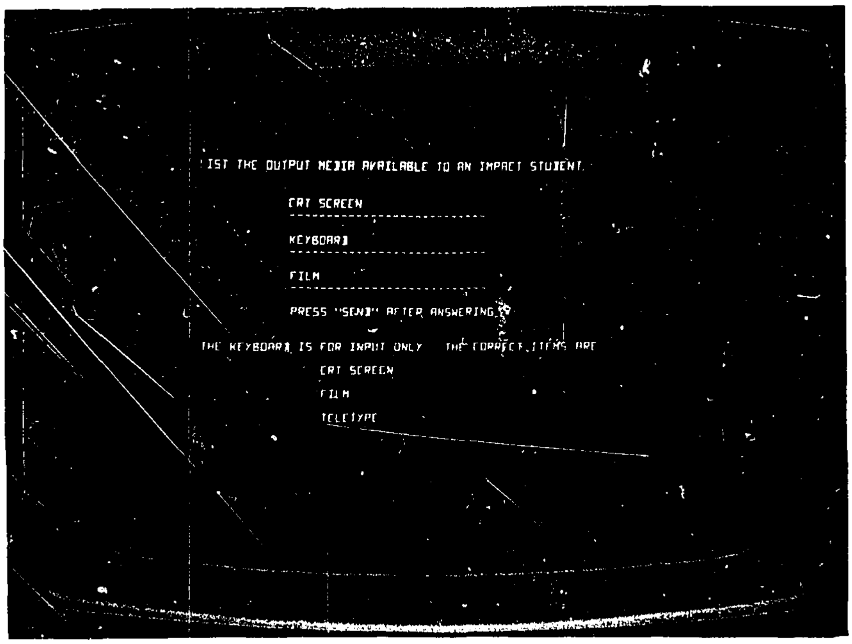


Figure 5

Film/Slide Projector

A motion sequence film or a frame of film may be projected in conjunction with a CRT display. The projector (Perceptoscope) operates under commands that are transmitted through the CRT circuitry (3).[4] Hence, the addressable frames and motion sequences may be synchronized with the instruction appearing on the CRT. The Perceptoscope provides the capability to project graphic and schematic information that is not easily conveyed through the alphanumeric text of the CRT display, and it may also be used in situations when color is a key element to communicating the instruction, to show a short movie, or to step through a sequence of frames at a controllable speed. Use of this device in a course being run under Project IMPACT is illustrated in Figure 6.

Use of the Perceptoscope

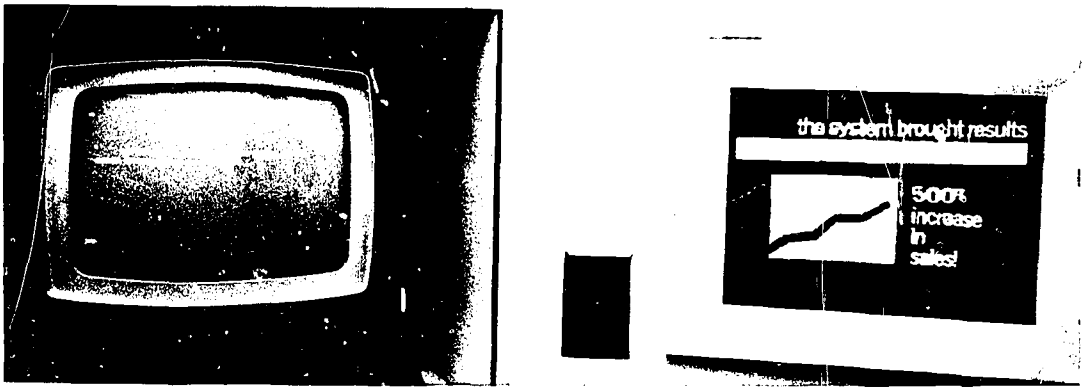


Figure 6

SOFTWARE SUPPORT FOR THE CRT

Zeus and DIRECTOR perform many functions needed to support multiple CRT terminals at remote locations. One of these functions is to retrieve course material from direct access storage and project it on the CRT screen to the student. DIRECTOR receives commands from the course program as to what instructional material is to be transmitted next. DIRECTOR locates that material in a file of preformatted text and transmits it to the student's CRT. These displays (elements of instructional text) are in a file separate from course logic. They may be recalled many times within a course of instruction. The software can string together various text elements to form a variety of total displays. This is one of the mechanisms by which a specific instructional presentation may be tailored to the needs of a particular student at a given point in time.

Zeus and DIRECTOR are designed to accept commands from course programs that contain the logic, or strategy, of a course of instruction. At present in Project IMPACT, course programs are prepared using the IMPACT-Coursewriter language. However, Zeus and DIRECTOR are designed to accept commands from any language; they are not restricted to IMPACT-Coursewriter operations. Any programming language that operates on the IBM 360 and is suitable for expressing the logic of a course of instruction may operate in conjunction with Zeus and DIRECTOR.

[4]The Perceptoscope cannot be used in conjunction with the IBM 1050 typewriter.

TYPES OF INSTRUCTIONAL OUTPUT

The foregoing devices and computer software provide for all types of instruction to be presented to the student, including:

(1) Explanatory text and graphics
(2) Remedial text and graphics
(3) True-false, multiple choice, and constructed response questions
(4) Quizzes and tests
(5) Study or homework assignments
(6) Exercises and drills
(7) Feedback on student performance; attention-getting cues
(8) Glossary definitions

CAPABILITIES FOR STUDENT INPUT

This section describes the means by which the student communicates with the computer, the types of input the student may enter, and the interpretation of student input by the computer.

HARDWARE DEVICES

The primary device for student input is the keyboard associated with the Sanders 720 CRT. (If the course is being administered via a 1050 typewriter, the input medium is, of course, the 1050 keyboard.)

The primary difference between typing on a CRT keyboard and typing on a typewriter is that with the former the *cursor* must be properly positioned on the CRT screen before the student can respond. The cursor is a pointer to the screen position where the input is to be entered. It appears as a single character, blinking underline. The IMPACT CAI system has three features that minimize the problem of cursor positioning for the student:

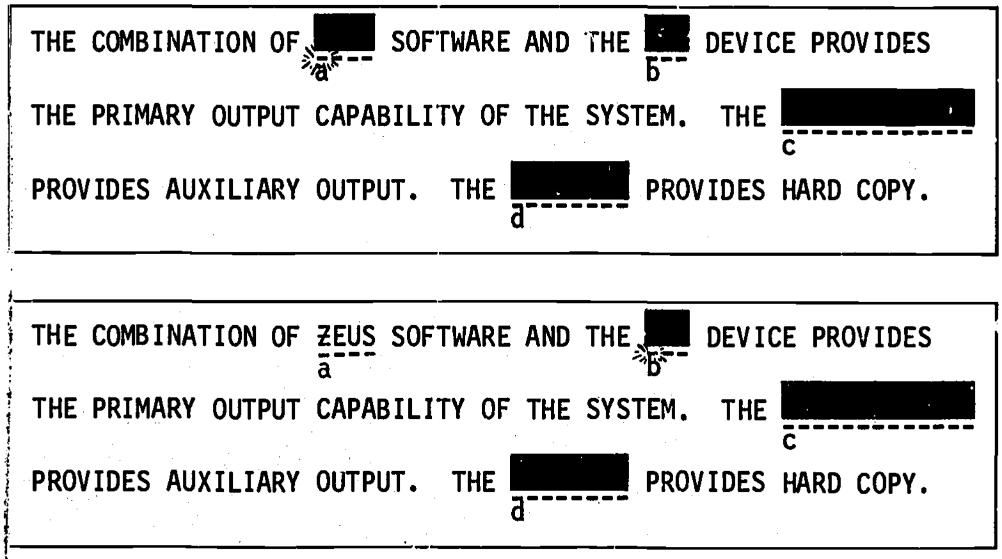
(1) DIRECTOR pre-positions the cursor at the exact spot on the screen where the student is to begin his response.

(2) The terminal is equipped with an electronic pen which the student may use to move the cursor to any position on the screen. (For example, the student may wish to move the cursor around to answer a series of questions in a different order than they are presented on the screen).

(3) The display may be formatted in a way that causes the cursor to automatically skip from one answer space to another. Figure 7 is an example of an instructional display that takes advantage of this capability.

The other devices—the tablet and voice input—are being developed to further open the channels of communication from the student to the computer. The tablet, called the "Sylvania Tablet" enables a student to hand print, rather than type, an input. Experimentation is underway to determine the extent to which this device improves communication between the student and the IDM. The voice input device allows a student to speak words from a prestored list, instead of using some form of hand input. The present vocabulary is limited to 25 words because of memory limitations. The recognition error rate is 1%.

Use of CRT Formatting to Control Cursor Positioning



(The cursor automatically moves to point b after blanks at a are filled in. Similarly with c and d. Students may override automatic cursor movement by using the electronic pen.)

Text of question

Student response block

Figure 7

TYPES OF STUDENT INPUT

The types of inputs the student may make are summarized in Figure 8. The uses of various types of input are in every case at the option of course designers, with the instructional strategy being the determining force.

The glossary requests may be made before the student answers a question, while he is reading the instructional text, or, at the course designer's option, during tests. The glossary request capability is built into DIRECTOR. It represents a first step in the direction of a generalized information retrieval capability for students.

If a student is having difficulty with a segment of the course, or finds any aspect of the system frustrating or confusing, he may choose to key in a *comment*. These comments are later reviewed by appropriate operations personnel or course authors, and used to make improvements in the system or to determine need for individual student counseling. (See Part 4, Evaluation.)

Summary of Types of Student Input With IMPACT-A HSSS

Class of Input	Specific Types	Constraints
Answers to Questions	Multiple choice True/false Matching Constructed response single word or several words Graphics formed from Sanders 720 characters	Line drawings may not be input, a constraint of the Sanders 720.
Inquiries	Glossary requests Requests for specific topics of instruction for review, or assignments. "HELP" requests, for a hint or explanation	Definitions are limited to 252 characters.
Comments	Any remark student wants to make about the course or system, may be entered at any time. System will not confuse comments with other responses.	Student receives no immediate feedback. The comments are reviewed offline by instructors.

Figure 8

INTERPRETING STUDENT INPUT

The flexibility of the tools available f interpreting student responses has a tremendous impact on the responsiveness of the CAI system to the student's learning requirements. At the simplest level, the expected responses to a question are prestored in the course program. The student's response is compared to the prestored words, and if a precise match is obtained, the student receives a correct answer score.

In order to eliminate some of the rigidity inherent in character-by-character comparisons, IMPACT-Coursewriter provides tools for scanning a response for key words or character strings, which effectively allow for variations in spelling and punctuation. However, the problem of having to prestore each word or phrase at each response point in the course still remains.

Project IMPACT has added a function called "SEEK" to Coursewriter language, which makes it easier to specify alternative responses. SEEK enables a course author to specify a list of response words that are common to a sequence of instruction and are used repeatedly.[5] A course segment coded with fn SEEK had six times fewer computer instructions than the same segment without fn SEEK.

[5] Function SEEK also has other uses, described in IMPACT's Coursewriter function documentation.

Categorization of Responses

Once the system has been able to identify a student response as meaningful, or anticipated, it can then categorize and store it. The IMPACT-A HSSS provides 80 counters for interpretive information for each student (an extension beyond Coursewriter III's 30 counters).

The use of these counters for response interpretation by the IDM is a matter of establishing conventions for a particular instruction segment. For example, it may be determined that there are 20 basic concepts in a particular segment. Separate counters may be established, by convention, to represent those concept categories. Each student response would be interpreted as indicating whether or not a particular concept was being grasped by the student. The counters would then be used as a factor in making decisions as to what instruction or test question to present next to the student.

"State of Knowledge" (SOK)

Other mechanisms may be built into courses for interpreting student responses. For example, in Project IMPACT's course in COBOL, each student's response includes a value for the confidence the student expresses in his answer. The response interpretation programs assign a "state of knowledge" (SOK) value to the response, which is a function of the correctness of the response and the student's confidence in the answer. The SOK is used by the IDM in making decisions about what instructional action to take next.

CAPABILITIES FOR MAKING INSTRUCTIONAL DECISIONS

The ability to make decisions that result in instruction tailored to the individual student is at the heart of Project IMPACT. This capability, the Instructional Decision Model (IDM), consists of rules for the computer system to use in deciding what to do next (4).

The major elements of the decision-making process are shown in Figure 9. The decision factors for use by the IDM, shown in Figure 10, encompass student performance data during the course of instruction as well as a profile of the student obtained at registration time. The theoretical underpinnings of an IDM are discussed in a number of works (5, 6, 7).

Analysis and decision-making actions taken by the IDM during the time the course is being administered to the student take place *online*. Additional analysis and decision making are performed *offline*, as a process separate from course administration, either by the computer (in batch operation) or manually. In other words, some decisions are made in real time, that is, in time to affect the instructional process for the student. Other decisions are made out of the time frame of actual course administration.

The decision factors listed in Figure 10 are those the IMPACT-A HSSS provides capability for using, either *online* or *offline*, as indicated. The *offline* factors are being studied as a part of Project IMPACT, and depending on the outcome of this research, the IMPACT-B HSSS will be expanded to provide for *online* use of the significant decision factors. For example, if response latency is demonstrated to be an important factor in deciding whether to present remedial instruction, the HSSS will be expanded to allow for latency as an *online* decision factor.

Entry characteristics, such as previous training and scores on standard tests, may be used to determine difficulty level and other characteristics of the material to be presented. Under IMPACT-A, researchers provide the interpretation, prior to registering a student for the course; however, under IMPACT-B much of this would become an *online* function.

Major Elements in Decision Making

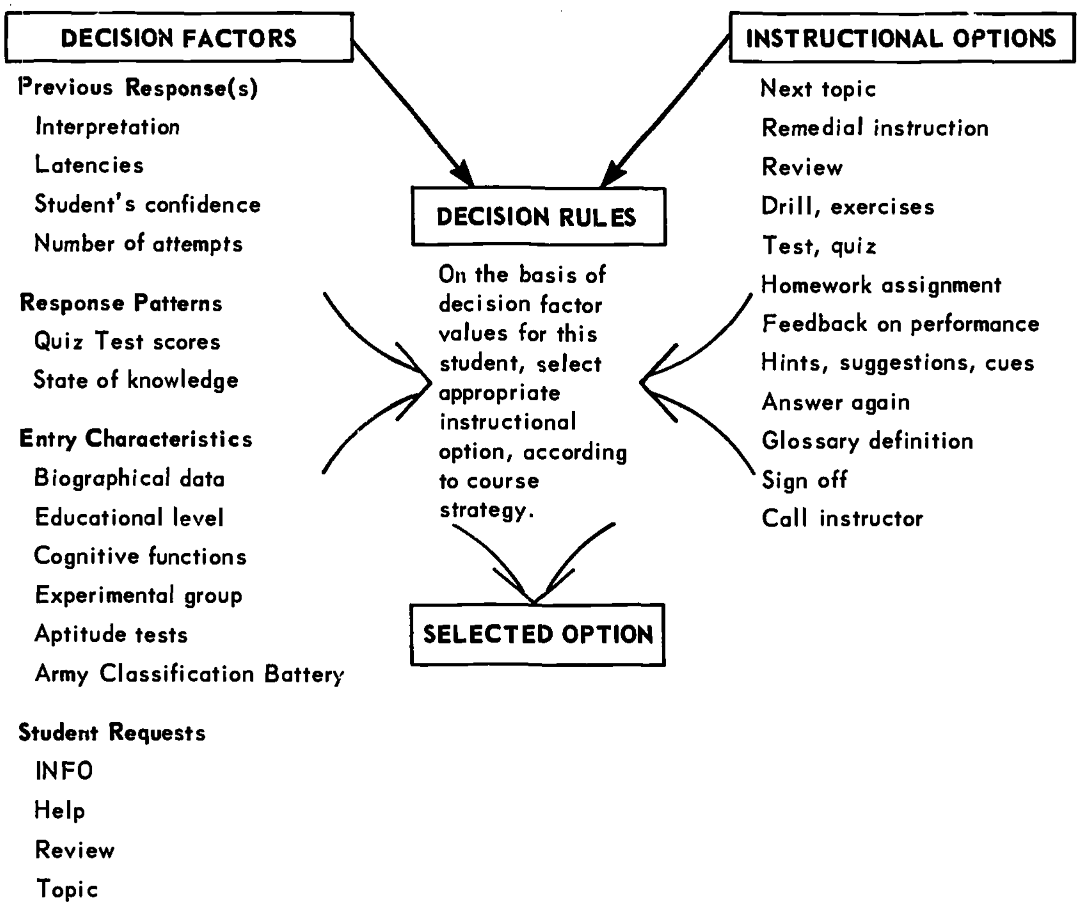


Figure 9

Every time a student makes an input, a decision point is reached. The greater the variety and number of instructional options that are available, the more refined the instruction can be in terms of meeting individual student needs. The kinds of instructional options that may be provided by IMPACT at any point in the course are theoretically unlimited. From the point of view of the HSSS, review material, drills or exercises, tests, new topics, homework assignments, and so on, are all the same. The capabilities of DIRECTOR for retrieving display elements from text files enable the IMPACT-A HSSS to provide a very high degree of flexibility in the number and kinds of options available at any decision point.

The decision-making process by which an instructional option is chosen and specific actions taken is illustrated in Figure 11. The output of the response interpretation consists of decision factor values stored in a series of counters. The counters are then an input to the IDM which relies on prescribed rules to make a choice among options. The decision is communicated to the Course Program, which in turn takes action through DIRECTOR. Then the student receives the tailored instruction presentation.

Decision Factors in IMPACT-A HSSS

Class	Factor	Description	Analysis	Decision Making
Previous Response (s)	Anticipated	Is response recognizable?	Online	Online
	Interpretation	Is a particular error or insight implied in the response?	Online	Online
	Latency 1	Time from transmission of question to student's acknowledgement.	Online	Offline
	Latency 2	Time from student acknowledgement of question to receipt of his response.	Online	Offline
	Confidence	Student's expressed confidence is his answer	Online	Online
	Number of attempts		Online	Online
Response Patterns	Quiz, test Scores	Individual scores or changes from test to test	Online	Online
	State of knowledge	Increasing, decreasing state of knowledge	Online	Online
Entry Characteristics	Biographical		Offline	Offline
	Educational	Grade level, previous training	Offline	Online
	Cognitive Functions	Results from psychometric tests	Offline	Offline
	Experimental group	Identity of student in an experimental or control group in a special study.	Offline	Online
	Aptitude tests	Results from aptitude tests	Offline	Offline
	Army Classification Battery	Results from Army Classification Battery	Offline	Offline
Student Requests	INFO	Request definition of term	Online	Online
	Help	Request help with a question	Online	Online
	Review	Request review of a topic	Online	Online
	Topic	Request topic of instruction	Online	Online

Figure 10

Steps in Decision Making in the IMPACT-A HSSS

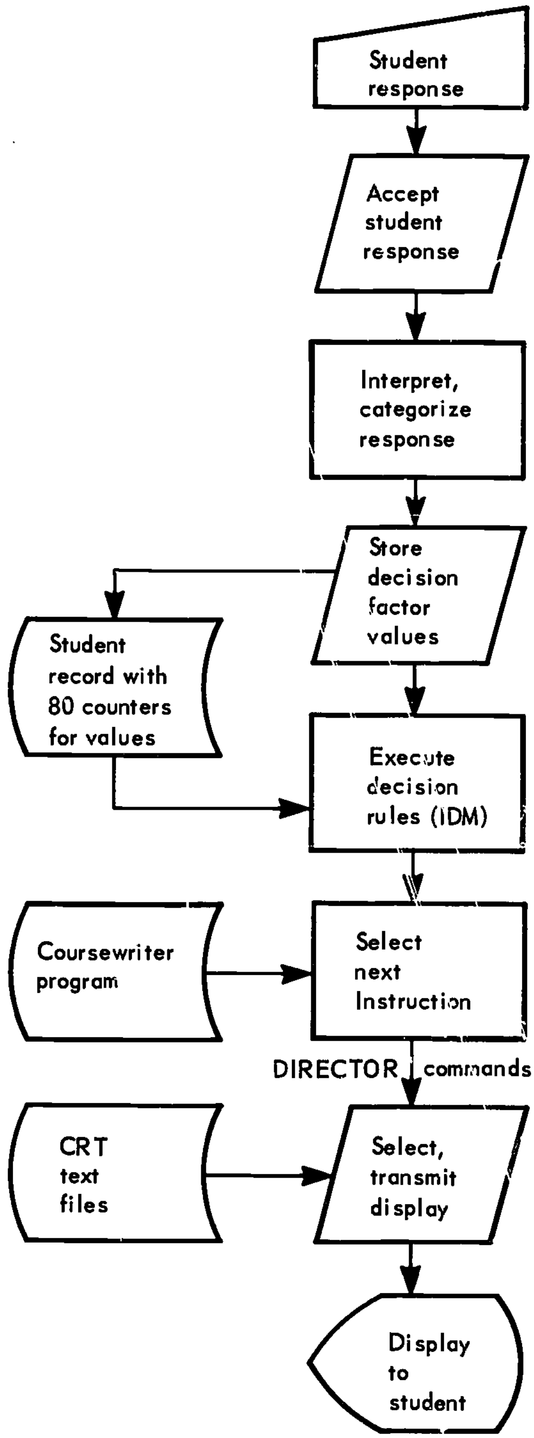


Figure 11

TESTING

The same capabilities that are used to administer instruction to students may also be used to administer tests. Quizzes, as well as phase or other criterion tests, may be automatically administered to the student at the time appropriate for him.

ADMINISTERING TESTS

Tests may be administered in a variety of ways. Test questions may be presented to the student on the CRT screen in much the same fashion as a paper-and-pencil test. Standard paper tests may be given to the student by his instructor, and the student may enter his answers on the CRT (or 1050 typewriter) keyboard. Where a performance test requires the student to manipulate offline devices (e.g., electronic test equipment), the student may enter answers or result values on the CRT keyboard. Multiple choice, true-false, or single or multiple word constructed response tests may be used. Multiple forms or versions of a test may be stored in the HSSS and different forms administered to different students, on either a random or preplanned basis.

SCORING AND GRADING

Students' answers to test questions are scored by the computer as soon as they are entered. In a course programmed in Project IMPACT, the scoring takes into account not only the actual answer given to a question, but also the confidence the student expresses in his answer (1, p. 18).

Scores may be computed for single answers, groups of answers, or any combination of answers. The grades on the test may be computed immediately by the computer system, or the raw scores may be provided to the instructors for their analysis and grading. The student may be informed of his score immediately after each question, after a test segment, after a test, or not at all, depending on school procedures and requirements.

STORING AND RETRIEVING TEST SCORES

The computer stores the test scores and/or grades in the student's record. Through the IMPACT Data Evaluation System (IDES), discussed in Part 4 of this report, test scores and grades may be retrieved in a variety of forms for different purposes. An individual's total test score or scores on individual test items may be printed out, or a listing of all students' scores and/or answers to individual test items may be retrieved. Other data may also be retrieved, such as the amount of time it took a student to answer a question, and, if relevant, the number of times he attempted to answer it.

Part 3

IMPACT-A HSSS CAPABILITIES FOR IMPLEMENTING COURSES

This section of the report describes the HSSS capabilities that assist in preparing CAI courses of instruction.

OVERVIEW

The major development steps in preparing a CAI course are shown in Figure 12, in gross terms. The term "instructional programming" is often used to describe the last two steps shown in the figure, writing and implementing CAI segments. Both steps are sometimes performed by the same person or persons. However, this presentation is directly concerned only with course implementation, the last step shown, which is in direct interface with the HSSS. The efficiency and cost of performing this step is directly related to the capabilities of the HSSS.

In Figure 13, the three major steps involved in course implementation are shown—formatting and entering CRT displays, coding and input of the course program, and testing and debugging. By separating these three steps, the IMPACT HSSS provides for more efficient and economical course implementation relative to other CAI systems.

Overview of CAI Course Development Steps

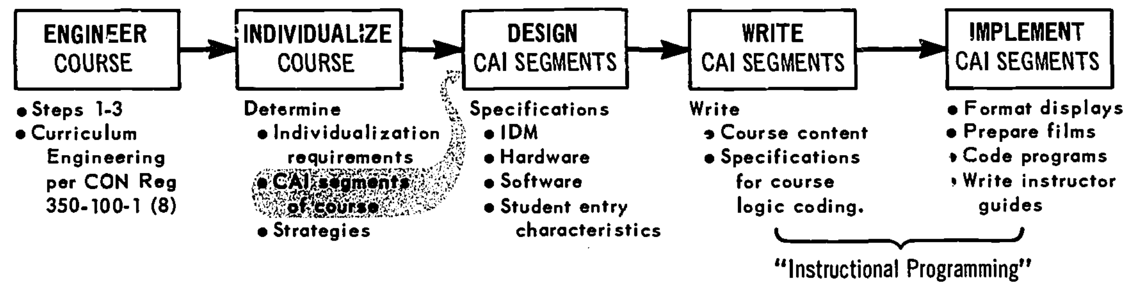


Figure 12

Major Steps in Course Implementation

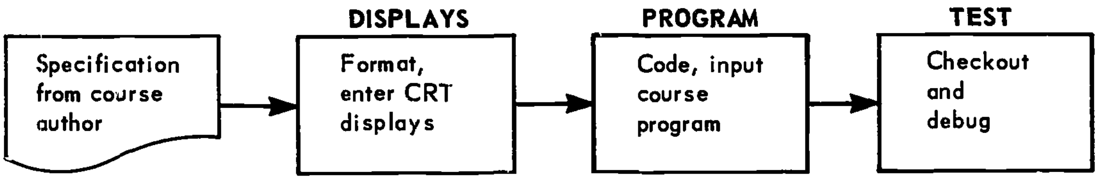


Figure 13

INSTRUCTIONAL DISPLAYS

The main HSSS components used to format and store CRT displays in the computer are shown in Figure 14. The person who is creating or modifying instructional content sits down at the CRT terminal and types in the exact text and format characters desired.

IMPACT-A HSSS Components Involved in Formatting and Storing CRT Displays

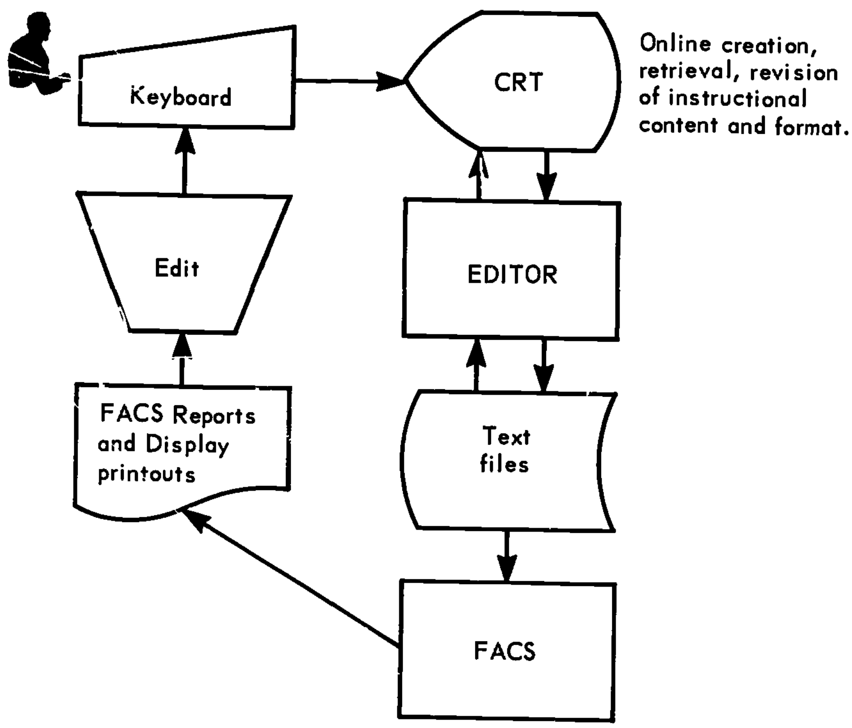


Figure 14

EDITOR COMMANDS (AUTHOR MODE OPERATIONS)

Through a simple command language (EDITOR),[6] the person formatting the page tells the computer to store it on file on magnetic disk (the "Author Mode" operation indicated in Figure 1b). EDITOR is a generalized display handling capability, which operates independently of the CAI system. Hence it may be used for a variety of applications other than CAI. Sample EDITOR commands are shown in Figure 15.

[6]The use of EDITOR is described in a HumRRO report, in preparation, on preparing and managing instructional content in the IMPACT text-handling subsystem.

Sample EDITOR Commands

Command	Explanation
CREATE D9999,'MUSICSCALES'	Create a display called "musicscales"
COPY D8888,D8889, 'SHARPS'	Make a copy of a display already stored, and give it the new name "sharps"
MODIFY D9999	Bring display D9999 to the screen; replace it with the modifications made.
DISPLAY D9999	Bring display D9999 to the screen.
DELETE D9999	Delete D9999 from the file.
ROLLON F7777,4,1	Retrieve display F7777 from the file; "roll it on" to the CRT screen in Block 4. Position the cursor at Block 1.

Figure 15

Example of a Display Printout Generated by FACS

```
OATE PRINTED 07/20/70      FACS                                                                        PAGE   1
OISPLAY NUMBEP                 TITLE                  OPERATION    OATE      TIME       AUTHOR
  001050         01050                                MOOIFIEO     07/20/70  09/50/10   DICK

 LINE   ---------1---------2---------3---------4---------5---------6---------7---------8----
   1   |LET'S REVIEW SOME OF THE IDEAS I HAVE PRESENTED.                                      |
   2   |                                                                                      |
   3   |    COMPLETE THE SENTENCES BELOW WITH THE FOLLOWING WORDS;                            |
   4   |                                                                                      |
   5   |                                                                                      |
   6   |        COBOL    COMPUTER    OATA PROC SSING    PROGRAM                               |
   7   |                                                                                      |
   8   |                                                                                      |
   9   |    GIVE A SHOW OF CONFIOENCE AFTER EACH ANSWER.  PRESS SENO AFTER EACH ANSWER.       |
  10   |                                                                   ----               |
  11   |                                                                                      |
  12   |1.  HANOLING LARGE AMOUNTS OF INFORMATION IS CALLEO X################   000    000   |
  13   |                                                                                      |
  14   |2.  A MACHINE THAT CAN PROCESS OATA RAPIOLY IS A    X################   000    000   |
  15   |                                                                                      |
  16   |3.  A SERIES OF STEPS FOR DIRECTING COMPUTERS IS A  X################   000    000   |
  17   |                                                                                      |
  18   |4.  THE PROGRAMS YOU WRITE WILL BE IN THE LANGUAGE  X################   000    000   |
  19   |                                                                                      |
  20   |                                                                                      |
  21   |PRESS SENO.                                                                           |
  22   |                                                                                      |
  23   |                                                                                      |
  24   |                                                                                      |
  25   |                                                                                      |
  26   |                                                                                      |
  27   |                                                                                      |
  28   |                                                                                      |
  29   |                                                                                      |
  30   |                                                                                      |
  31   |                                                                                      |
  32   |INFO-                                                                                 |
        ---------1---------2---------3---------4---------5---------6---------7---------8----
NUMBER OF BLOCKS=   6

OELAY LINE:
---------1---------2---------3---------4---------5---------6---------7---------8---------9---------0---------1---------2---------3--
6DICK           095010640070201 1   D1050                                                      VVCCCHHHHHHHHHHHHHX#############
###H000H000MVVVCHHHHHHHHHHHHHX################H000H000MVVVCCCHHHHHHHHHHHHHX################H000H000MVVVVCHHHHHHHHHHHHHX#############
###H000H000MVVVVVVVCCCINFO-                                      MLET'S REVIEW SOME OF THE IDEAS I HAVE PRESENTED.CCHCOMPLETE THE
SENTENCES BELOW WITH THE FOLLOWING WOROS:CCCHHCOBOLHCOMPUTERHOATA PROCESSINGHPROGRAMCCCHGIVE A SHOW OF CONFIOENCE AFTER EACH ANSWER.
  PRESS SEND AFTER EACH ANSWER.CHHHHHHHHHHHHHHHH   ----CC1.  HANDLING LARGE AMOUNTS OF INFORMATION IS CALLFOCC2.  A MACHINE THAT CAN
 PROCESS DATA RAPIDLY IS ACC3.  A SERIES OF STEPS FOR DIRECTING COMPUTERS IS ACC4.  THE PROGRAMS YOU WRITE WILL BE IN THE LANGUAGE C
CCPRESS SEND.MVVVVVCC                                                                                       C
                                                        C
       C                                                      X

---------1---------2---------3---------4---------5---------6---------7---------8---------9---------0---------1---------2---------3--

  001050                                                                                 TITLE: 01050
```

Figure 16

FILE ACTIVITY CONTROL SYSTEM

Thousands of display pages are usually needed in a long course of instruction. FACS (File Activity Control System) is a set of computer programs that provides information about the display pages that have been stored on disk. FACS helps in editing and coordinating the displays. The following are examples of the information FACS provides:

(1) A list of all displays by name, which have been created, revised, or deleted since a specified date.

(2) A list of all displays created by a given author.

(3) A condensed version of a series of related displays.

(4) A printed copy of all or selected displays in the format in which they appear on the CRT screen, along with pictures of the displays as they appear in computer memory. Administrative information is also provided, such as name of the display, author, date last modified, and number of characters in the display.

(5) A list of displays, by name, that contain a specified word or series.

The FACS output has a variety of uses such as editing displays, scheduling course implementation activities, supervising the implementation team, and revising a course. Figure 16 shows an example of a FACS printout.

EDITING

Editing is facilitated by the combined use of FACS and EDITOR commands. Authors review FACS printouts of the instructional content and mark corrections on the hard copy. Through EDITOR commands, the original display can be called to the CRT screen and modified or deleted. Many such modifications may be made without changing the course organization or course programs.

COURSE LOGIC

Course programs contain the logic of a course—the rules for analyzing student responses, rules for making instructional decisions, and instructions on recording data.

The programs are a series of instructions, usually written in the Coursewriter III author language (9). Coursewriter III is the special-purpose CAI language developed by IBM for use on the 360 computer (Coursewriter I and II were for the 1401 and the 1500 computers). Project IMPACT has extended the capabilities of Coursewriter III to support CRT terminals and to make course programs more efficient. Hereafter this is referred to as IMPACT-Coursewriter. An example of a part of an IMPACT-Coursewriter program is presented in Figure 17.

Embedded in the IMPACT-Coursewriter input-output instructions are commands to DIRECTOR, which tell DIRECTOR what CRT display text to retrieve from the text files and transmit to the student. Hence actual text is kept apart from the course programs. Coursewriter programs are ordinarily written on coding sheets and then keypunched. The punched cards are processed by a special Coursewriter program that assembles and stores the course program on disk.

IMPACT-Coursewriter programs may also be input via a CRT or the 1050 typewriter. This procedure is used primarily for making short insertions, deletions, or modifications to a course program.

Sample Portion of IMPACT-Coursewriter Program

DXP40	
1- 0 RD ((DIS D 365,1),(SET GLOS=0))	(Command to DIRECTOR to transmit display)
1- 1 EP	(Command to poll student for response)
1- 2 FN RECORD	(Store a copy of the student's record)
DBP22	
1- 0 QU ((DIS D260,1),(SET GLOS=0))	(Command to DIRECTOR to transmit question)
1- 1 EP	(Poll student for response)
1- 2 ED CH*/CH*/CH*	(Instructions for recognizing student's response)
1- 3 LD DBP24/R1	,,
1- 4 LD 33/C69	,,
1- 5 AA (L) WORKING*STORAGE* &	,,
1- 6 LD 1/S1	,,
1- 7 LD 4/B1,52,1	(Load decision factor values into student's record)
1-1- 8 BR VAL02	(Transfer control to IDM)

Figure 17

COURSE CHECKOUT AND DEBUG

CAI courses, like any computer program, must be tested and debugged to ensure that the program is coded correctly and the displays properly synchronized with the logic.

The separation of text and logic makes this debug operation more efficient than in standard Coursewriter systems. The IMPACT-Coursewriter programs may be debugged online, via 1050 or CRT, with only the titles of the displays being printed out; or the total course, including displays, may be tested via the CRT. The tester signs on the course as a student and tests various paths through the instruction. Via EDITOR and IMPACT-Coursewriter he can make corrections to either displays or logic directly on the terminal.

Part 4

IMPACT-A HSSS CAPABILITIES FOR EVALUATING INSTRUCTION

BACKGROUND

One of the most significant characteristics of computer-administered instruction is the fact that the instructional system has built into it the capability for collecting data needed to evaluate its own effectiveness. The effectiveness of the instruction can be continually monitored and evaluated, and the instructional programs continually revised and improved.

The computer's powerful capabilities for collecting, storing, and manipulating data are widely recognized as being of tremendous potential value in helping to evaluate the instruction the computer administers. At the same time, if such data are to be usable for evaluation, the data must be *managed*, that is, stored, structured, extracted, summarized, and retrieved in terms that are meaningful for the purpose at hand. Data management, then, is an important function of the IMPACT HSSS. To the HSSS, the problem of evaluation is a problem of data management (Figure 1c, "Evaluation Mode").

HSSS DATA MANAGEMENT CAPABILITIES

The IMPACT-A HSSS data management capabilities are a combined function of the IMPACT-Coursewriter system's capabilities for collecting and recording data, IMPACT Data Evaluation System's (IDES) capabilities for structuring and retrieval, and the statistical analysis capabilities of the BMD package (10). An overview of these capabilities is shown in Figure 18.

DATA COLLECTION

Every time a student interacts with the computer, IMPACT-Coursewriter records information about that interaction. This feature is controlled so that an instructor or researcher may select the type of interaction to be recorded. For example, he may choose to have a recording made only when the student makes a mistake.

Project IMPACT has added to the basic Coursewriter III recording mechanism the capability to specify the exact point in the instructional program at which a recording is to be made. This adds considerable flexibility and generality to the basic Coursewriter recording feature. Each time IMPACT-Coursewriter makes a student recording (Figure 19), it stores 500 characters of data.

IMPACT-Coursewriter writes these 500-character records on magnetic tape or disk, in the sequence in which the instructional interactions occurred. For example, a recording for Student 111 at Frame 63 may be followed by a recording for Student 112, at Frame 14, followed by a recording for Student 554 at Frame 87 in another course.

IMPACT-A Data Management and Evaluation Overview

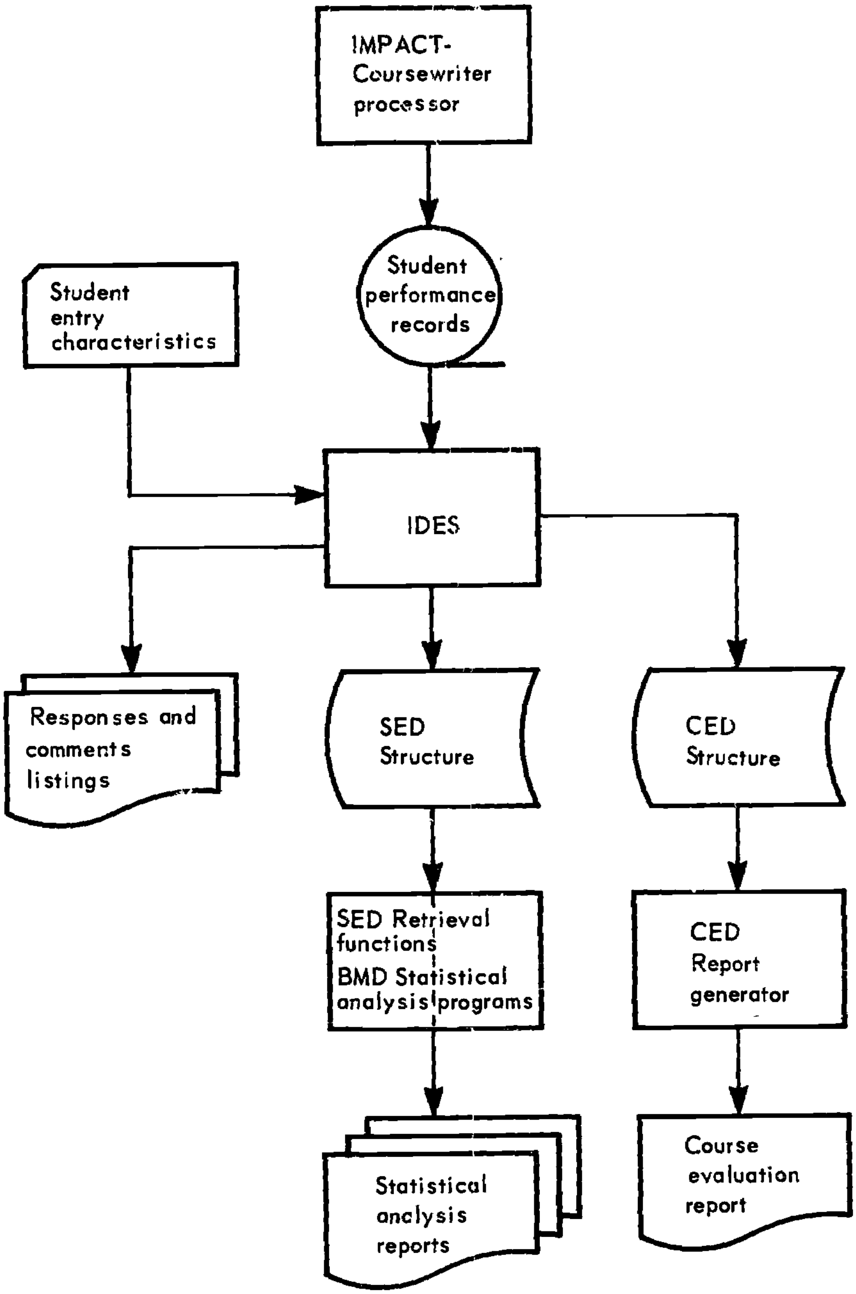


Figure 18

Data Items in Student Performance Recordings

- Student Name
- Student Number
- Group Number
- Course Name
- Course Segment
- Date student registered
- Last date student signed on
- Current Date
- Label identifying where student is in course
- Last question student answered
- Student's response to last question
- Number of attempts at current question
- Time student signed on
- Current time
- Total time student has spent on course
- Decision factor values
  (6 registers, 81 counters, 32 switches, 32 parameters)
  (100 characters of error codes)

Figure 19

IDES

These sequential student recordings are the primary input to IDES, a set of computer programs that organizes the data into comprehensive structures, and provides for retrieval of selected and summarized information from the data structures (Figure 20). Two data structures are produced—the Course Evaluation Data structure (CED) and the Student Evaluation Data structure (SED). At the time a day's response recordings are being structured by IDES, IDES also prints out a listing, by student, of responses and comments for the day.

DATA STRUCTURES

The CED is structured by IDES into lists of data cells (via list-processing subroutines called SLIP, 11) with the key item being a *question* or unit in the course. A schematic of the CED is shown in Figure 21. This data structure is designed to provide extracts, summaries, and analysis of performance across students within a course item.

The SED is organized into SLIP lists with *student* identity being the key item. The SED contains not only the data provided by response recordings, but also biographical data, entry characteristics, and follow-up data obtained offline and entered via punched cards. A schematic of the SED is shown in Figure 22.

Overview of IDES

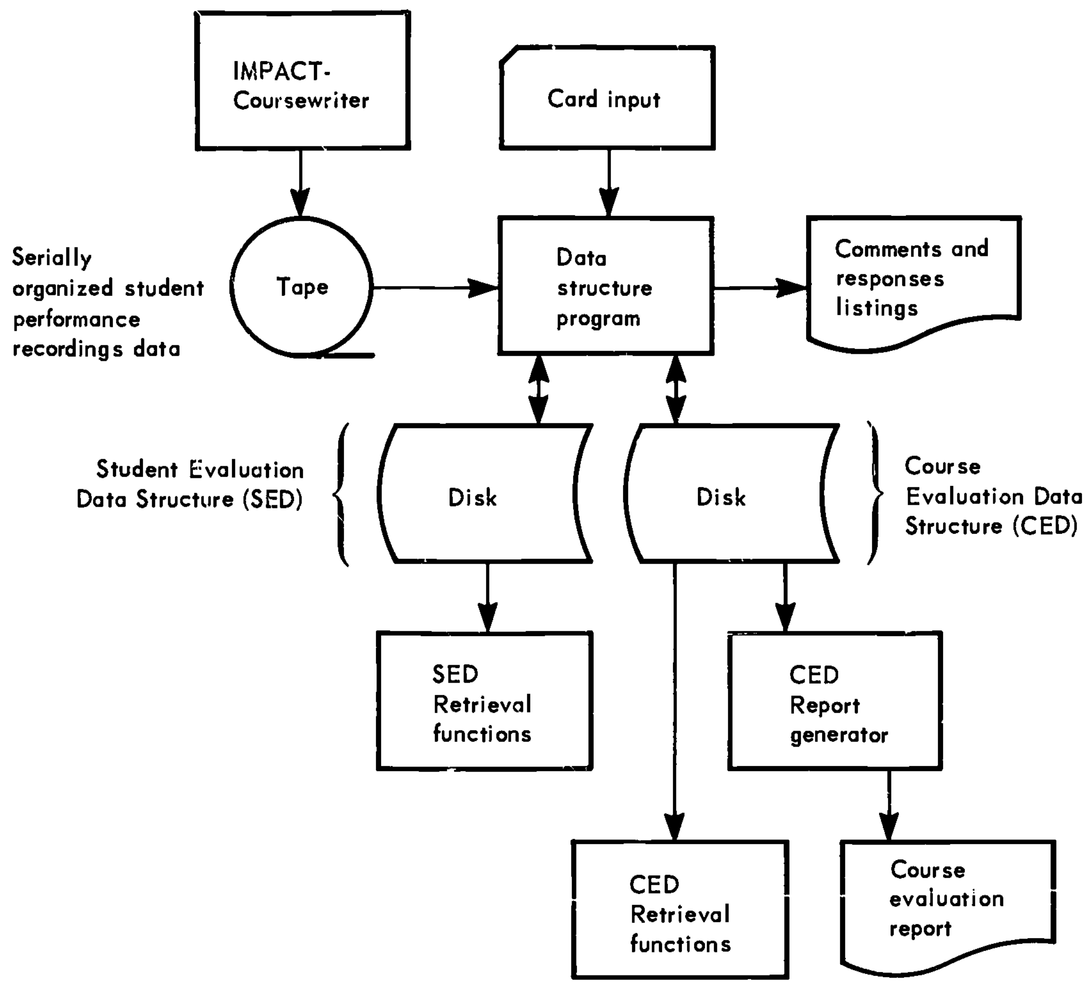


Figure 20

Course Evaluation Data Structure

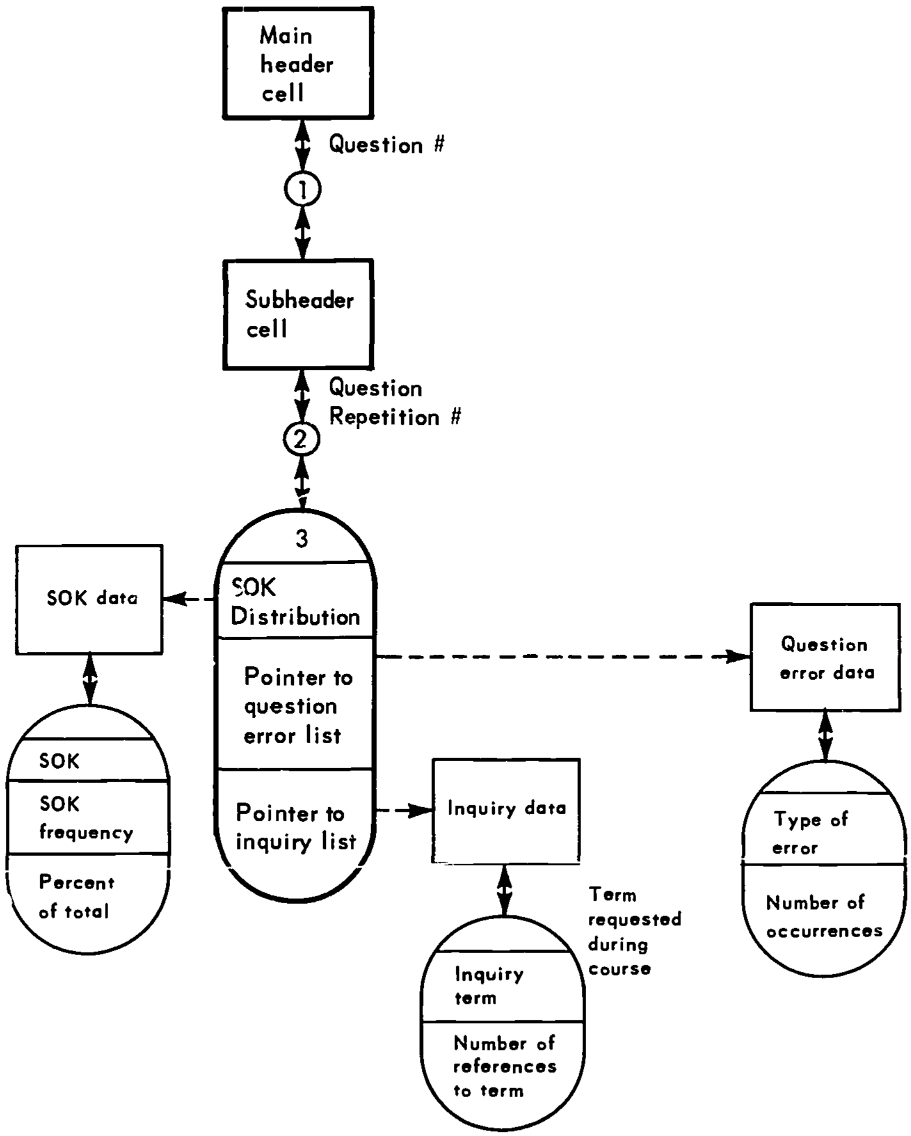


Figure 21

Student Evaluation Data Structure

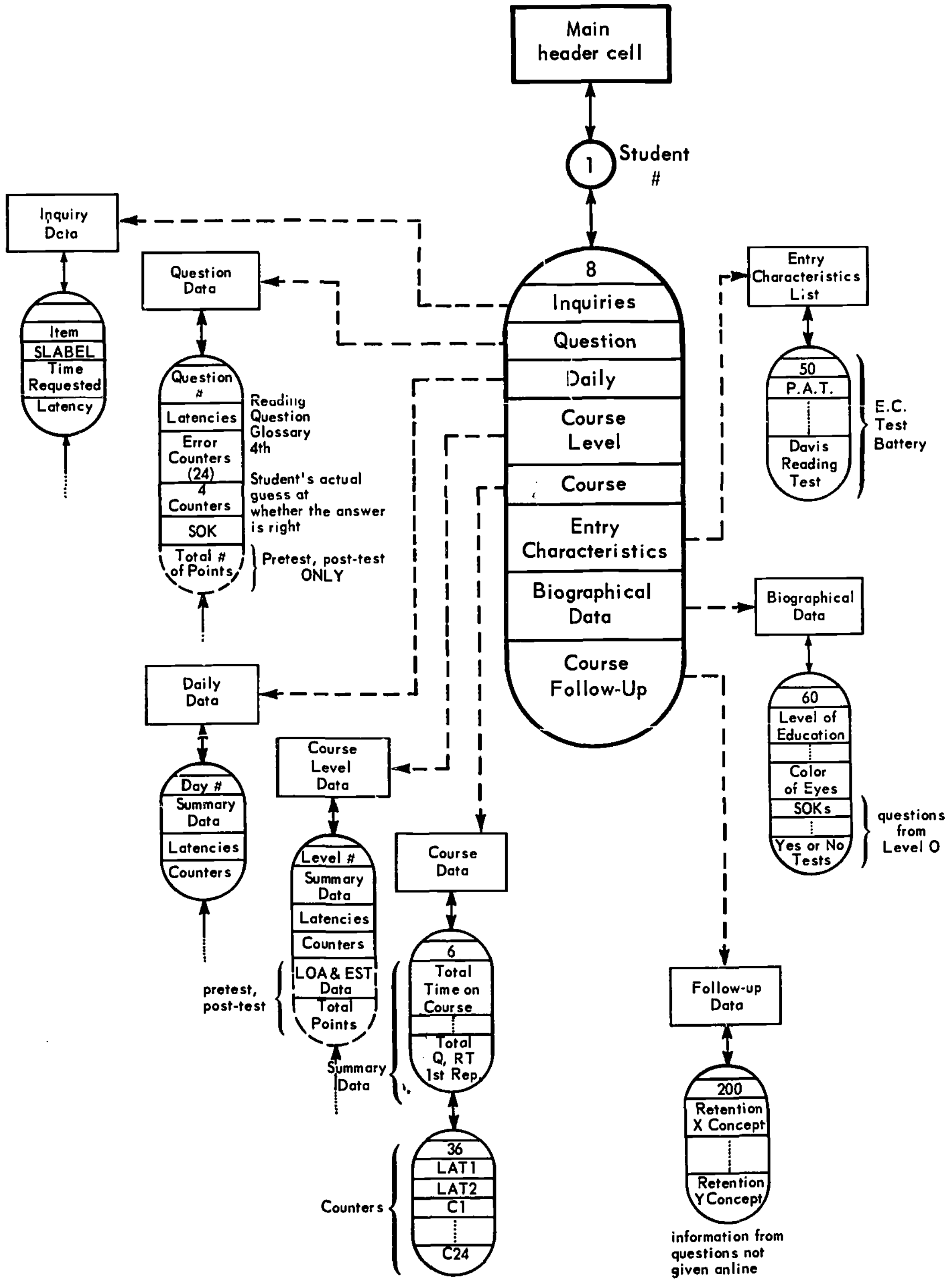


Figure 22

RETRIEVAL

For course and IDM evaluation purposes, there are several types of reports that may be produced from the data structures.

The comments and response listing shows, for each student, the actual text of his comments and responses in the order in which they occurred (Figure 23). It is extremely valuable to instructional programmers in checking on the effectiveness of individual items or units within the course.

Sample Student Response Output

STUDENT RESPONSE LISTING PAGE 1

STUDENT NO. 9997 COURSE COBOL LEVEL 12 DATE 3 JULY 1970

Type material	PRESENTATION	FLAG	STUDENT INPUT	TIME
Display (text)	D1047		@@I THINK I UNDERSTAND	14:17
Question	Q1050A	NR	MOVE A TO B	14:19
Feedback	F113		@@WHY IS THE CONTENT OF A STILL THERE?	14:19

Figure 23

The unanticipated glossary requests listing shows words for which the students requested definitions that the system was not able to supply. It provides a mechanism for continual updating and improvement in the glossary and in the course material.

The CED printout of which Figure 24 is an example, is the primary tool for the instructional programmers in evaluating individual frames of instruction.

The CED printout shows the state-of-knowledge distribution across students on the item, the types of errors made by all students, and the requests for glossary information made by the students. Six "knowledge states" are provided for each attempt at answering the question. Knowledge states can be interpreted in any way desired by the course developers—for example, Project IMPACT's COBOL course defines knowledge states as a function of the student's expressed confidence in his answer, combined with the correctness of the response.

Alternative uses might include a combination of aptitude classification with correctness, a simple right-wrong categorization, or substantive classifications of correctness related to the subject matter. The report shows the number and percentage of students in each state of knowledge for each attempt at answering the question. (Some course strategies allow for the student to answer the same question several times until he gets it correct.)

The error summary shown on the CED printout is extremely valuable in detecting the need for additional remediation sequences in the course, or for improving explanations of specific points. The error types may be defined in any way specified by course developers, and may be as refined as desired. Glossary references also provide quick information on the need for improvements in the course text on various points.

CED Output Format

COURSE EVALUATION DATA FOR QUESTION Q1050A

69/08/15 PAGE 29

STATE OF KNOWLEDGE DISTRIBUTION

	ATTEMPT NUMBER															
STATE	1		2		3		4		5		6		7		TOTAL	
	F	P	F	P	F	P	F	P	F	P	F	P	F	P	F	P
WIF	10	50.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	10	33.3
INF	3	15.0	2	33.3	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	5	16.7
PIN	3	15.0	1	10.7	0	0.0	1	100.0	0	0.0	0	0.0	0	0.0	5	16.7
UNI	2	10.0	3	50.0	1	33.3	0	0.0	0	0.0	0	0.0	0	0.0	6	20.0
MIS	1	5.0	0	0.0	1	33.3	0	0.0	0	0.0	0	0.0	0	0.0	2	6.7
HMI	1	5.0	0	0.0	1	33.3	0	0.0	0	0.0	0	0.0	0	0.0	2	16.7
TOTAL	20	100.0	6	100.0	3	100.0	1	100.0	0	0.0	0	0.0	0	0.0	30	100.0

MEAN POINTS 4.3 6.2

ERRORS FOUND IN STUDENTS ANSWERS

ERROR NUMBER	ERROR TITLE			NUMBER OF ERRORS ON ATTEMPT 1	2	3	4	5	6	7
6 9 7	FORM	VARIOUS	EVALUATN	2	1	3	0	0	0	0
8 8 8	OTHER	OTHER	OTHER	11	3	1	0	0	0	0
2 3 5	ADD	NAMES	ANALYSIS	0	1	2	0	0	0	0

GLOSSARY REFERENCES

ITEM NAME	NUMBER OF REFERENCES
COBOL	1
FORTRAN	1
READ	7

F = Frequency of students
P = Percentage of students
WIF = Well informed
INF = Informed
PIN = Partially informed
UNI = Uninformed
MIS = Misinformed
HMI = Highly Misinformed

Figure 24

SED Retrieval is highly dependent on the requirements of a particular course or IOM evaluation study. The SED is so comprehensive that each evaluation study must specify the exact extraction, summary, and analysis needed for that particular study (Figure 22).

Retrieval functions, a part of the IDES package, assist in extracting the specific data items needed from the SED. These items may be printed out either in detailed or in summary fashion, (e.g., a listing of an individual's grades on quizzes and tests) or they may be processed by statistical packages. At Project IMPACT, the BMD statistical analysis package (10) is used to produce various statistical reports from SED data (Figure 25).

A wide range of evaluation studies can be performed using data in the SED in combination with the BMD statistical analysis package. For example, response measures (latency, particular errors, patterns of responding, expectations by the student, and so on) can be related to pre-course student history, within-course student history, achievement criterion measures, and other factors in the IDM used to make instructional decisions.

The variety of techniques available in the BMD analysis system makes it possible to explore joint effects of several variables (multivariate analysis), the effects of qualitative or categorical variables (contingency analysis), mathematical formulations of stages of learning (time series analysis), the unique patternings of students' characteristics (factor

List of Statistical Analyses Performed by BMD

Description and Tabulation

Simple Data Description
Correlation with Transgeneration
Correlation with Item Deletion
Alphanumeric Frequency Count
General Plot Including Histogram
Description of Strata
Description of Strata with Histograms
Cross-Tabulation with Variable Stacking
Cross-Tabulation, Incomplete Data
Data Patterns for Dichotomies
Data Patterns for Polychotomies

Multivariate Analysis

Principal Component Analysis
Regression on Principal Components
Factor Analysis
Discriminant Analysis for Two Groups
Discriminant Analysis for Several Groups
Canonical Analysis
Stepwise Discriminant Analysis

Regression Analysis

Simple Linear Regression
Stepwise Regression
Multiple Regression with Case Combinations
Period Regression and Harmonic Analysis
Polynomial Regression
Asympototic Regression

Time Series Analysis

Amplitude and Phase Analysis
Autocovariance and Power Spectral Analysis

Variance Analysis

Analysis for Variance for One-Way Design
Analysis of Variance for Factorial Design
Analysis of Covariance for Factorial Design
Analysis of Covariance with Multiple Covariates
General Linear Hypothesis
General Linear Hypothesis with Contrasts
Multiple Range Tests
Analysis of Variance

Special Programs

Life Table and Survival Rate
Contingency Table Analysis
Biological Assay: Probit Analysis
Guttman Scale Preprocessor
Guttman Scale #1
Guttman Scale #2, Part 1
Guttman Scale #2, Part 2
Guttman Scale #2, Part 3
Transgeneration
Transposition of Large Matrices

SOURCE: Reference 10.

Figure 25

analysis), relationships between individual characteristics of the student such as expectancies in relation to actual performance (correlational and regression analysis). The BMD analysis system will be extended in Project IMPACT to increase the precision of estimating stages in the learning process (Bayesian and conditional probability analyses); these additions to BMD will allow use of formal mathematical models of the learning process.

Taken as a whole, evaluation studies provide the mechanism for a continuous refinement of IDM and overall efficiency of the IMPACT computer-administered instructional system.

Part 5

IMPACT-A HSSS CAPABILITIES FOR SUPPORTING SCHOOL ADMINISTRATION

Although not explicitly designed as an administrative record keeping system, the IMPACT-A HSSS, in conjunction with the instructional process, keeps records that are useful for administrative purposes. A fully operational CAI system will be designed to interface smoothly and directly with school administration and operations. The capabilities described here are a step toward that objective (see Figure 1d, "Support Mode").

REGISTRATION

Students are registered for a course through a course supervisor who enters special commands into the computer. One student or a group of students may be registered in one command, either through the 1050 typewriter or the CRT. When a student is registered for a course, the IMPACT-Coursewriter administrative software creates an identification record for him, which the system continuously updates as the student progresses through the course. Some of the items of information in that record are shown in Figure 26.

Information Items in Student Identification Record

- Course Name
- Course Segment
- Student Name
- Date Registered
- Last date student was using course
- Student's Group number
- Student's Identification number
- Where student is in the course
- Current date
- Time of day student last signed on to course
- Total time, in minutes, student has spent on course to date
- Student's response to last question
- Performance date–status of counters and switches and error codes

Figure 26

INQUIRIES

A supervisor or instructor may inquire as to the status of a student (9). At the CRT or 1050 typewriter, he keys in the inquiry using the Supervisor's Command Language. The status report tells where the student is in the course, how long he has been on the course (actual minutes of instruction), when he was last on the course, and the date on which he started it (Figure 27).

Example of System Response to Student Status Inquiry

GROUP	COURSE	LOCATION	START DATE	LAST DATE	TIME	TYREC	STUDENT NO.	STUDENT NAME
RJS	DAR2	0- 1	6/ 5/70	6/24/70	0:37	0	1970	GROUP 1
RJS	F0034	0- 2	6/15/70	6/16/70	1: 8	0	1971	GROUP 2
RJS	DAP18	1- 1	6/11/70	6/26/70	1:10	0	1972	GROUP 3
RJS	TEMP1	1- 1	6/15/70	7/13/70	9:41	0	11001	NEIL ZAREMBA
RJS	DXC60	1- 1	6/22/70	6/26/70	10:13	0	11002	CHARLES JONES
RJS	HMS	1- 1	6/23/70	6/26/70	8:13	0	11003	RICHARD CAMPBELL
RJS	PLACE	0- 2	7/ 2/70	7/10/70	13:17	0	11004	DOUG SHAWN
RJS	TEMP1	1- 1	6/30/70	7/ 9/70	7:26	0	11005	DOUG SPENCER
RJS	D2131	1- 1	7/ 7/70	7/10/70	11:57	0	11007	GARY WOLFE
RJS	Q2691A	1- 1	7/13/70	7/17/70	13:14	0	11008	DAVID KOPSTEIN
RJS	D24352	1- 1	7/13/70	7/17/70	13:53	0	11009	JEFFREY SEWARD
RJS	D1380	1- 1	7/13/70	7/16/70	4:15	0	1944	DOUG ROBINS

Figure 27

The Project IMPACT staff is now designing computer software algorithms that will predict the date at which a student will complete the course, based on his performance to date. This prediction would be added to the status report.

In a CAI system with remote student stations in different buildings or geographic locations it is useful to be able to locate a student or determine the status of the stations. An inquiry can be made that tells a supervisor or instructor who is using which stations at a given point in time.

ACADEMIC RECORDS

Grades on quizzes, exercises, phase tests, or other tests are stored by the system in the student record files. Attendance data is also recorded, showing date, time of day, and duration of each student session. These data may, with some modification in the present SED structure, be stored and retrieved in various detailed or summary reports for academic record keeping (see Part 4). Such data may be used by the instructor for his record keeping, or may be used directly by the school administrative office for academic records. In schools where the Academic Records Application of the CONARC Educational Data System (CONEDS) has been implemented, IMPACT-B would provide compatible data interface with CONEDS (12).

Part 6

OPERATIONAL SUMMARY

It is commonly recognized that if a CAI system is to be not only effective as an instructional method, but also efficient and economical for use by Army schools, the system must have a very large operating capacity. The larger the system in terms of numbers of students it can accommodate and numbers of courses available, the more economical it is on a *per student basis* (13).

With this premise in mind, development of the IMPACT CAI system began with a medium-large scale computer that is typical of the kind that would be required in a large scale CAI system. The CRT device is of the general type that could be used in large numbers and at locations remote from the central computer.

From an operations standpoint, the IMPACT-A HSSS can be described as evolutionary. That is, although some characteristics of the hardware and computer software are experimental in nature, they are designed to provide a basis for evolution to a large scale, efficiently operating system. For example, the Sanders CRT, which is currently an important part of the system, is a general-purpose alphanumeric device, with many varied and flexible capabilities. Project IMPACT will determine which of these capabilities are really needed for implementation of effective operational CAI. The result of this study and experience will be design recommendations for a CRT that is tailored to Army CAI requirements.

HARDWARE SUMMARY

The central processing computer is a moderate-size third-generation computer, the IBM 360 Model 40 (14). It has 256,000 bytes of internal storage. Auxiliary storage is provided by an IBM 2314 direct access storage device, containing eight disk drives (15), each drive having a capacity of 23,000,000 bytes. There are four 2401-IV (120KB) magnetic tape drives. Input and output to student stations is provided through the Sanders 731 Communication Buffer (for CRTs) or the IBM 2701 Data Adapter (for 1050s[7]). Telecommunications lines connect the Sanders 731 to the Sanders 701 Control Units located near the CRT terminals. Each 701 controls three Sanders 720 CRTs (16) and one teletypewriter for hard copy of information on the screen. (The IMPACT-A hardware configuration is shown in Figure 28.)

Various capabilities of the IMPACT student stations have been mentioned throughout this report. The functions of the Sanders 720 Terminal (viewing, presentation, format, and control) are described in Figure 29.

[7] The 1050 terminal configuration was deleted from the system, for budgetary reasons, as of 1 July 1970.

IMPACT A Hardware Configuration

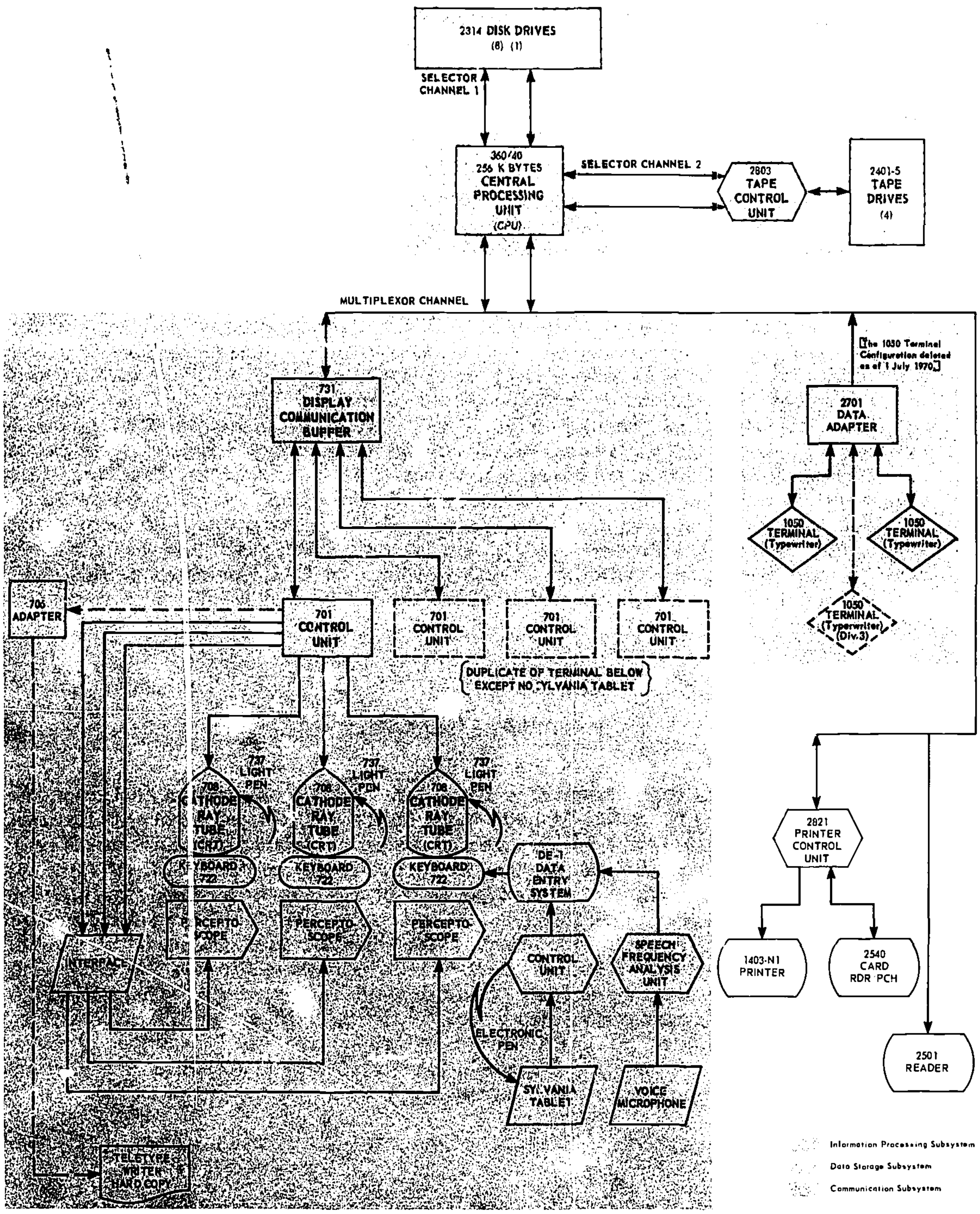


Figure 28

Sanders 720 Terminal Summary

Function	Description
Viewing	Screen color grey. Adjustments for horizontal, vertical, and brightness. The screen size is 7½ by 9½ inches.
Presentation	Of the screen's 2,048 character positions, 1,024 may be used for information to be presented and control characters.
	The screen may be divided into a number of individually addressable blocks. The character positions forming a block need not be contiguous.
	Emphasis is obtained by use of the blinking feature in which individual characters or words may be caused to blink.
Format	Extensive formatting capability is available through the use of edit control characters for horizontal and vertical spacing, cursor positioning, etc.
Control	Control over student using the keyboard is accomplished through a hardware feature that provides two modes of operation. In the student (Edit-1) mode, the student cannot destroy the presentation format.
	The student can be prevented from moving the cursor outside the block he is currently working from the keyboard.
	The light pen allows the cursor to be moved to any point on the screen.

Figure 29

SOFTWARE SUMMARY

When CAI is operating with student stations, for administering courses, or for author use, the modules used are: IMPACT-Coursewriter, Zeus, DIRECTOR, EDITOR, and Operating System/360. IDES and FACS operate offline—that is, independently of Coursewriter, Zeus, and the student stations. (The components and functions of the computer software subsystem are reviewed in Figure 30.) Each of the software components is identified in Figure 31 in terms of its origin, dependencies and status.

IMPACT Computer Software Configuration

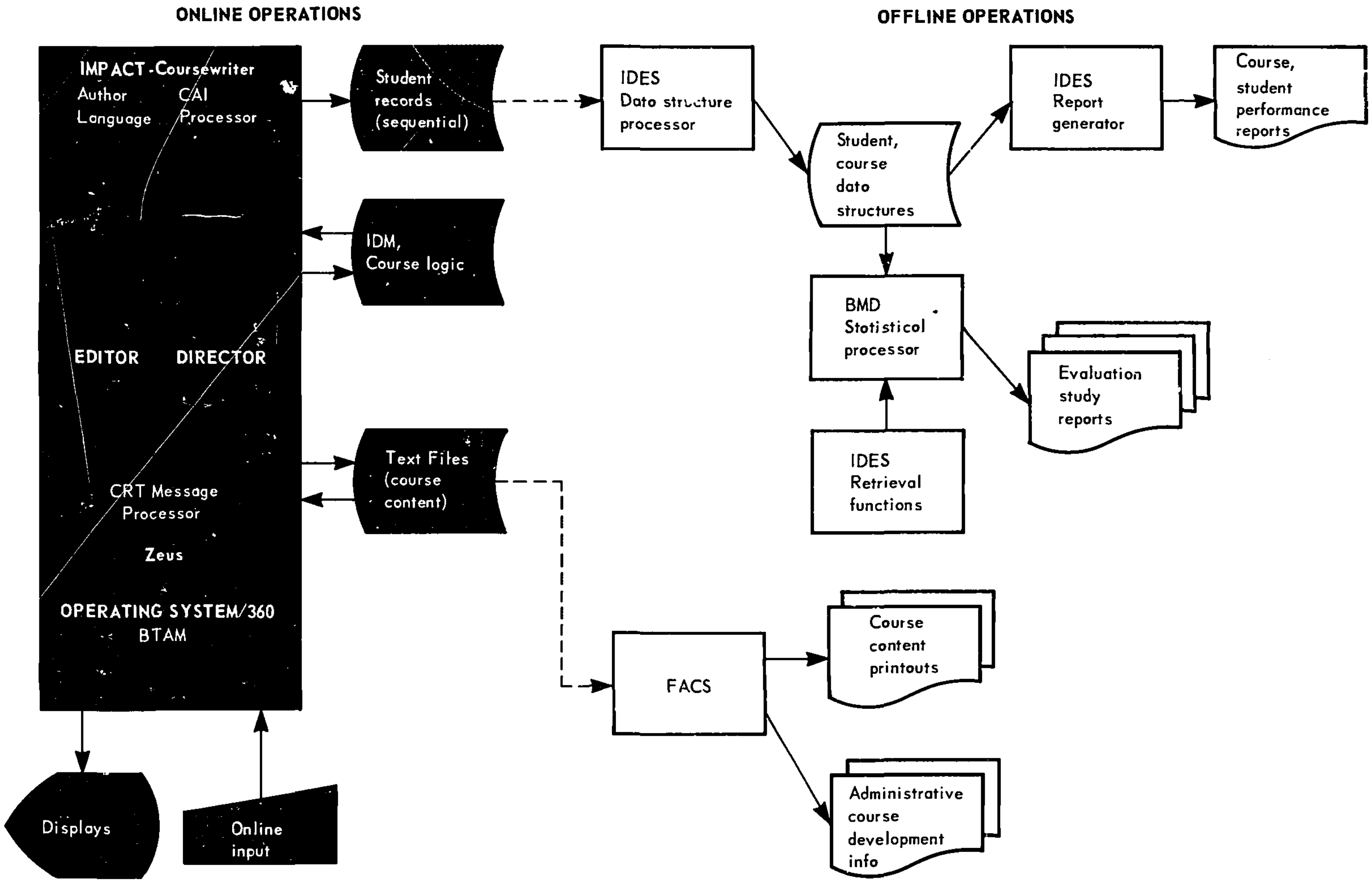


Figure 30

**Summary of Software Components—
Dependencies, Status, and Availability**

Component Name	Origin	Hardware Dependencies	Software Dependencies	Status
360 Operating System	IBM	360/40	None	Latest version
Coursewriter III Version I	IBM	IBM 360 1050	OS/360	Released, type III documented not supported by IBM
IMPACT-Coursewriter	IMPACT	IBM 360	OS/360	Operational, documented
IMPACT-Coursewriter functions	IMPACT	IBM 360	IMPACT–Coursewriter	Operational, documented for users and programmers
Zeus Supervisor°	IMPACT	IBM 360 Sanders 720 CRT	OS/360	Operational, evolving
EDITOR Commands	IMPACT	IBM 360 CRT	OS/360 Zeus	Operational
DIRECTOR	IMPACT	IBM 360 CRT	OS 366 Zeus	Operational, evolving
IDES	IMPACT	IBM 360	Fortran IV IMPACT–Coursewriter SLIP	Operational, documented
FACS	IMPACT	Sanders 720 CRT IBM 360	PL-1 Zeus	Operational

°Not available for release at this time.

Figure 31

OPERATIONAL CHARACTERISTICS

MODES OF OPERATION

Actual instruction and course preparation activities may take place simultaneously, that is, students may be receiving instruction on some display consoles while courses are being formatted and coded on others. A number of different courses may be administered simultaneously. The system allows multiple applications to share the main computer, that is, IMPACT and unrelated jobs may be conducted at the same time (for example, administrative record keeping and other computational batch processing jobs).

CORE REQUIREMENTS

The IMPACT software system requires approximately 100,000 bytes of core (about one-half of the total available for applications, since the IBM 360 Operating System requires approximately 50,000).

NUMBER OF STUDENTS

The number of students that can be handled at one time is a function of the number of student stations that the system has online and the number of students that can share a terminal.

Number of Student Stations. There is no theoretical limit to the number of CRT terminals that can be connected to the computer. However, there is a practical maximum, with the response time as the constraining factor. The greater the number of terminals on a line, the slower will be the response time as the waiting time increases.

The number of student stations supported in the system is a critical factor for operational CAI. This will be a major consideration in IMPACT-B design.

Registration Limit. Up to 999 students may be registered for a given course at any point in time.

Location of Student Stations. The terminals can be either local (close to the computer) or at remote sites via telecommunication lines.

DIRECT ACCESS STORAGE

Instructional Text. The amount of course material that may be available to students at any point in time depends on the amount of direct access storage available. The IMPACT configuration has eight disk packs on the IBM 2314. The capacity of each disk pack is 23,000,000 bytes. (Each pack has 230 times the storage of one disk cartridge on the IBM 1500.) About 20,000 full pages of CRT text can be stored on one of these disk packs.

Hours of Instruction. The translation from bytes of storage to hours of instruction is not a direct one. There are a great many variables affecting the hours of instruction provided so that one particular hour of instruction may require 10 or 20 times more disk storage than another hour of instruction. However, it is estimated that several thousand hours of instructional material may be stored at one time on the IMPACT-A configuration.

Instructional Program. Disk storage is also required for the course logic (Coursewriter program and IDM). Each instruction within the program typically requires from 15 to 20 bytes of storage. One hour's worth of instruction requires anywhere from 700 to 1,000 program instructions. Therefore a thousand hours of instruction would require from 10,500,000 to 20,000,000 bytes of storage for the Coursewriter program and IDM. This is less than one 2314 disk pack.

RESPONSE TIME

The response time is defined as the time interval between the instant a student presses the "Send" key on the keyboard to the instant the initial response from the computer is projected to him. The primary factors within the HSSS that affect response times are:

(1) Number of students online at any one time.
(2) Number of computer interactions with each student per unit time.
(3) The rate at which data is transmitted.
(4) The length of student responses.
(5) The computer program time to analyze the response, and make instructional decisions.
(6) Time required to access disk files.

The response time for a given IMPACT configuration may be predicted through simulation.

OTHER OPERATIONAL CONSIDERATIONS

On the basis of experience with IMPACT-A HSSS, the requirements for and design of the next generation prototype (IMPACT-B) will be prepared. The IMPACT-B HSSS will include provisions for some functions and capabilities needed in an operational Army environment that are *not* a part of the IMPACT-A system. These are:

(1) Security. The handling of classified instructional materials, not within the IMPACT-A system capabilities, will be addressed in the requirements analysis for IMPACT-B.

(2) Fallback and Recovery. The ability to return to a minimum operation when certain system components fail, and to recover from disaster conditions, will be addressed in IMPACT-B requirements and specifications.

(3) Reliability. The minimum standards for reliability of individual components and the total system, in an operational environment, will be a part of the IMPACT-B specifications.

(4) Interface With CONEDS. The Academic Records Application of the computer-based CONARC Educational Data System is currently operational in some Army schools (12). IMPACT-B will be designed to provide a compatible data interface with the Academic Records Application.

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AND
APPENDICES

LITERATURE CITED

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Appendix A

GLOSSARY

CAI	Computer-Administered Instruction. An individualized system of instruction in which the computer presents instruction to a student on the basis of his progress and other characteristics.
CED	Course Evaluation Data. A file containing summary data on student performance in a CAI course of instruction; used to evaluate and improve courses of instruction. The CED is structured and managed by IDES and is stored in computer-readable form on magnetic disk.
COBOL	Common Business Oriented Language. A standard computer programming language used by the Army for nearly all nonscientific computer applications such as supply, accounting, and personnel.
Counters	Computer storage spaces used to store data on a student's performance during a course.
Coursewriter III	A computer software package developed by IBM for instructional applications on the IBM 360 computer.
CRT	Cathode Ray Tube. This device is similar to a television screen, and is used to communicate from computer to student. The CRT has an associated typewriter-like keyboard through which the student communicates with the computer.
DIRECTOR	A software supervisor that retrieves the appropriate course content for an individual student and transmits it to his station. It is in interface between course programs and IDM, the course materials, and the student.
Display	Any material projected onto a CRT screen.
EDITOR	Entry on Disk of Instructional Text for Online Retrieval. A set of commands that enables course authors to create and modify course materials on the CRT and have them stored on disk at the central computer.
FACS	File Activity Control System. A set of computer programs that provides information about the display pages that have been stored on disk and helps in editing and coordinating the displays.
HSSS	Hardware/Software Subsystem. A subsystem of a total CAI system. The total system includes hardware, computer software, instructional materials, rules for administering the instruction, and students.
IDES	IMPACT Data Evaluation System. A set of computer programs that manages the data collected, stored, and processed by the CAI system.

IDM	Instructional Decision Model. A set of rules for determining what instruction to present next to a student, based on a combination of such factors as his performance during the course, his aptitude test scores, and his requests for assistance.
IMPACT	Instructional Model Prototypes Attainable in Computerized Training. The advanced development project in CAI at HumRRO.
IMPACT-Coursewriter	The Coursewriter III software package as used at Project IMPACT. The major difference between IMPACT-Coursewriter and Coursewriter III is the addition of the capability to use CRT terminals as the interface with the student.
Modes	Author Mode. When instructors or researchers are interacting with the computer, preparing instructional text or logic, the system is said to be in author mode. Student Mode. When the computer and student are interacting during the course of instruction, the system is said to be in student mode. Evaluation Mode. When the computer system is preparing reports or statistical analyses of student performance for research and evaluation purposes, it is said to be in evaluation mode. Support Mode. When members of the school or CAI center interact with the computer to get administrative information about students or other aspects of the system, it is said to be used in support mode.
Offline	Any process, activity, or device that is not online in the interactive sense defined below. Offline processes may be performed by man, computer, or other devices.
Online	A person or machine interacting directly with a computer, usually over a communications line; also, a process or activity performed in or with the computer, while the computer interacts with persons or machines through a communications line. The process or activity must affect the computer-man interaction in order to be considered online (e.g., batch operations such as FACS operating in background mode, even though they physically share the computer with online operations, are not considered to be online).[1]
Page	All the material projected at one time on a CRT screen.
SED	Student Evaluation Data. A file containing both detailed and summary data on students and their performance in CAI courses of instruction; used to evaluate individual and groups of students, courses of instruction, and instructional decision models. The SED is structured and managed by IDES and is stored in computer readable form on magnetic disk.
SEEK	A computer software function developed at Project IMPACT to assist in the implementation of instructional programs.

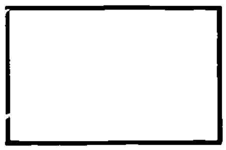
[1] There are more narrow definitions of online in terms of input-output hardware connected directly to a computer; however, they are not useful in distinguishing between processing modes.

SLIP	A collection of computer software subroutines used in computer programs that manipulate complex lists of data items.
SOK	State of Knowledge. A way of categorizing a student's knowledge or skill based on his actual performance of a task and on his own confidence in his ability to perform the task.
Zeus	A computer software monitor that makes it possible to operate multiple CRT terminals from locations remote from the central computer.

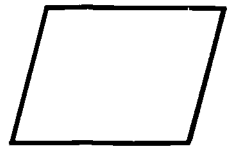
Appendix B

KEY TO FLOWCHART SYMBOLS

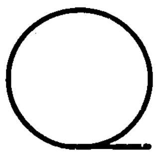
Processing



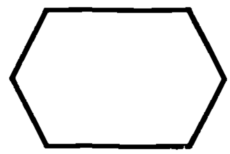
Input/ Output



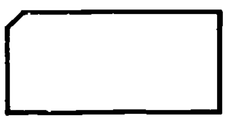
Magnetic Tape



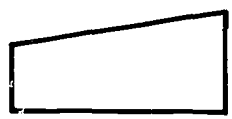
Preparation



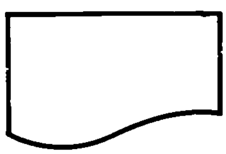
Punched Card



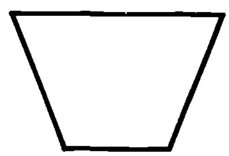
Manual Input



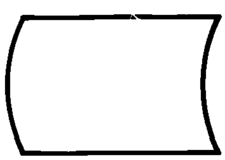
Printout



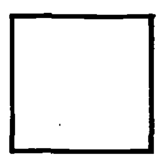
Manual Operation



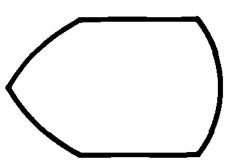
Online Storage



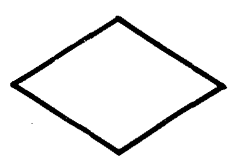
Auxiliary Operation



Display



Decision



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13. ABSTRACT

Project IMPACT is a comprehensive advanced development project designed to produce an effective and economical computer-administered instruction (CAI) system for the Army. In this report the computer hardware and software capabilities of the prototype system are described. The components of the computer hardware/software subsystem are discussed in terms of the four main activities they support. These activities are: (a) Administering instruction to students, (b) implementing courses into CAI format, (c) evaluating students, courses, and instructional decision models, and (d) performing administrative functions in a school.

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
CAI Hardware						
CAI Software						
Communications						
Computer-Administered Instruction (CAI)						
Coursewriter						
File Activity Control System (FACS)						
Hardware/Software Subsystem (HSSS)						
IMPACT Data Evaluation System (IDES)						
Information Processing Subsystem						
Instructional Decision Model (IDM)						

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1 CINC US EUROPEAN COMD ATTN SUPPORT PLANS BR J3
1 CINC USA PACIFIC ATTN G3 CDC APO SAN FRAN 96610
2 CG SOUTHERN EUROPEAN TASK FORCE APO 09168 NY
1 CG US ARMY JAPAN APO 96343 SAN FRAN ATTN G3
10 CG USA FORCES SOUTHERN COMD ATTN SCARCD FT AMADOR CZ
2 CG US ARMY EUROPE APO 09403 NY ATTN OPNS DIV
1 CO ARMY TRANS RES COMD FT EUSTIS ATTN TECH LIB
1 CG US ARMY AD COMD ENT AFB ATTN ADGCB
6 CG 1ST ARMY ATTN DCSOT FT MEADE MD
1 CG 3RD ARMY ATTN DCSOT FT MCPHERSON
2 CG 4TH ARMY ATTN AKADC-B(UT) FT SAM HOUSTON
1 CG FOURTH ARMY FT SAM HOUSTON ATTN G3
2 CG FIFTH ARMY FT SHERIDAN ATTN ALFGC TNG
1 CG EUSA ATTN AG-AC APO 96301 SAN FRAN
1 DIR HEL APG MD
1 CG USA CDC EXPERIMENTATION COMD FT ORD
2 ENGNR PSYCHOL LAB PIONEERING RES DIV ARMY NATICK LABS NATICK MASS
1 TECH LIB ARMY NATICK LABS NATICK MASS
2 INST OF LAND CBT ATTN TECH LIB FT BELVOIR VA
1 REDSTONE SCIENTIFIC INFO CTR US ARMY MSL COMD ATTN CHF DOC SEC ALA
1 CO USAPA MBLTV DET TOBYHANNA ARMY DEPOT
1 CO FT HUACHUCA SPT COMD USA ATTN TECH REF LIB
12 CO 1ST AIR DEF GUIDED MSL BRGD TNG FT BLISS
1 SIXTH USA LIB DEPOT BLDG M 13 14 PRES OF SAN FRAN
1 PLANS OFFICER PSYCH HDQTRS USACDCEC FORT ORD
5 CG FT ORD ATTN G3 TNG DIV
1 DIR WALTER REED ARMY INST OF RES WALTER REED ARMY MED CTR
2 DIR WRAIR WALTER REED ARMY MED CTR ATTN NEUROPSYCHIAT DIV
1 CO HQ ARMY ENLISTED EVAL CTR FT BENJ HARRISON
1 TECH LIB BOX 22 USACDC EXPERIMENTATION COMD FT ORD
1 HUMAN FACTORS TEST DIV (ADHZ) USAF HOSP EGLIN AFB
1 CO FRANKFORD ARSNL ATTN SMUFA-N6400/202-4
3 6TH RGN USARADCOM FT BAKER
1 4TH ARMY MSL COMD AIR TRANSPORTABLE SAN FRAN
1 DIR ARMY BD FOR AVN ACCIDENT RES FT RUCKER
2 CO PICATINNY ARSNL DOVER N J ATTN SUMPA VCI
1 DEF SUPPLY AGY CAMERON STATION ATTN LIB
2 CO USA CDC AG AGCY FT BENJ HARRISON IND
1 REF M MS IS NASA ALA
1 CBT OPRS RES GP USACDC SP OPRS ANALYST HUMAN FACTORS ALEX VA
1 CO ARMY CDC INF AGY FT BENNING
1 CO ARMY CDC ARMOR AGY FT KNOX
1 EVAL DIV OAD ARMY SIG CTR + SCH FT MONMOUTH
1 CO US ARMY CDC AVN AGCY FT RUCKER
15 CG USA TNG CTR AD ATTN ACOFS G3 FT BLISS
1 CG USA TNG CTR ARMOR ATTN ACOFS G3 FT KNOX
12 CO USA TNG CTR (FA) ATTN ACOFS G3 FT SILL
1 CG USA TNG CTR & FT LEONARD WOOD ATTN ACOFS G3
1 CG USA TNG CTR INF ATTN ACOFS G3 FT BENNING
1 CG USA TNG CTR INF ATTN ACOFS G3 FT DIX
1 CG USA TNG CTR ATTN ACOFS G3 FT JACKSON
1 CG USA TNG CTR INF ATTN ACOFS G3 FT LEWIS
1 CG USA TNG CTR INF & FT ORD ATTN ACOFS G3
30 CG USA TNG CTR INF ATTN ACOFS G3 FT POLK
5 CO USA MED TNG CTR ATTN DIR OF TNG FT SAM HOUSTON
1 CG USA TNG CTR INF ATTN ACOFS G3 FT BRAGG
1 CG USA TNG CTR INF ATTN ACOFS G3 FT CAMPBELL
2 CIVLN PERS OFCR US ARMY SPT CTR ST LOUIS ATTN EMPLOYEE DEVEL OFCR
3 LIB ARMY WAR COLL CARLISLE BKS
1 COMDT COMD + GEN STAFF CO FT LEAVENWORTH ATTN ARCHIVES
1 DIR OF MILIT PSYCHOL + LDRSHP US MILIT ACAD WEST POINT
1 US MILIT ACAD WEST POINT ATTN LIB
1 COMDT ARMY AVN SCH ATTN DIR OF INSTR FT RUCKER
2 COMDT ARMY SECUR AGY TNG CTR + SCH FT DEVENS ATTN LIB
1 MED FLD SERV SCH BROOKE ARMY MED CTR FT SAM HOUSTON ATTN STIMSON LIB
3 DIR OF INSTR ARMOR SCH FT KNOX
1 COMDT ARMY ARMOR SCH FT KNOX ATTN WEAPONS DEPT
1 COMDT USA CHAPLAIN SCH ATTN DOI FT HAMILTON
1 COMDT ARMY CHEM CORPS SCH FT MCCLELLAN ATTN EDUC ADV
1 COMDT USA FIN SCH ATTN CHF DOC DEV LIT PLN DIV IND
1 USA FINANCE SCH FT BENJ HARRISON ATTN EDUC ADV
4 COMDT ARMY ADJ GEN SCH FT BENJ HARRISON ATTN EDUC ADV
1 EDUC ADV USAIS ATTN AJIIS-H FT BENNING
1 DIR OF INSTR USAIS ATTN AJIIS-D-EPRD FT BENNING
1 HQ US ARMY ADJ GEN SCH FT BENJ HARRISON ATT COMDT
1 LIB ARMY QM SCH FT LEE
1 COMDT ARMY QM SCH FT LEE ATTN EDUC ADV
1 COMDT ARMY TRANS SCH FT EUSTIS ATTN EDUC ADV
1 CO USA SEC AGY TNG CTR & SCH ATTN IATEV RSCH ADV FT DEVENS
1. COMDT ARMY MILIT POLICE SCH FT GORDON ATTN DIR OF INSTR
2 COMDT US ARMY SOUTHEASTERN SIG SCH ATTN: EDUC ADVISOR FT GORDON
1 COMDT USA AD SCH FT BLISS
1 CO USA ORD CTR & SCH OFC OF OPS ATTN AHBN-O APG MD
5 ASST COMDT ARMY AIR DEF SCH FT BLISS ATTN CLASSF TECH LIB
4 CG USA FLD ARTY CTR ATTN AVN OFCR FT SILL
1 COMDT ARMY DEF INTEL SCH ATTN SI+AS DEPT
1 COMDT ARMED FORCES STAFF COLL NORFOLK
1 COMDT USA SIG CTR & SCH ATTN DOI FT MONMOUTH
1 COMDT JUDGE ADVOCATE GENERALS SCH U OF VA
1 DPTY COMDT USA AVN SCH ELEMENT GA
1 DPTY ASST COMDT USA AVN SCH ELEMENT GA
1 USA AVN SCH ELEMENT OFC OF DIR OF INSTR ATTN EDUC ADV GA
1 EDUC CONSLT ARMY MILIT POLICE SCH FT GORDON
6 COMDT USA ENGR SCH ATTN EDUC ADV FT BELVOIR
2 COMDT US ARMY SCH EUROPE ATTN REF LIB APO 09172 NY
1 CHF POLICY + TNG LIT DIV ARMY ARMOR SCH FT KNOX
1 COMDT ARMY AVN SCH FT RUCKER ATTN EDUC ADV
1 COMDT ARMY PRIMY HEL SCH FT WOLTERS
1 DIR OF INSTR US MIL ACAD WEST POINT NY
1 DIR OF MILIT INSTR US MILIT ACAD WEST POINT
1 USA INST FOR MIL ASSIST ATTN LIB FT BRAGG
4 USA INST FOR MIL ASSIST ATTN COUNTERINSURGENCY DEPT FT BRAGG
1 ARMY SIG CTR + SCH FT MONMOUTH ATTN TNG LIT DIV OAO
2 COMDT USA MSL & MUN CTR & SCH ATTN CHF OFC OF OPS REDSTONE ARSNL
2 COMDT US WAC SCH US WAC CTR ATTN AJMCT FT MCCLELLAN
2 HQ ABERDEEN PG ATTN TECH LIB
1 COMDT USA INTELL SCH ATTN DIR OF ACADEMIC OPS FT HOLABIRD
1 COMDT USA INTELL SCH ATTN DIR OF DOC & LIT FT HOLABIRD
1 COMDT USA C&GSC OFC OF CHF OF RESIDENT INSTR FT LEAVENWORTH
1 COMDT USA CA SCH ATTN DEPT OF RSCH ANALYSIS & DOC FT GORDON
1 COMDT USA CA SCH ATTN DOI FT GORDON
1 COMDT USA CA SCH ATTN EDUC ADV FT GORDON
1 COMDT USA CA SCH ATTN LIB FT GORDON
1 COMDT USA SCH & TNG CTR ATTN ACOFS G3 TNG DIV FT MCCLELLAN
1 COMDT USA SCH & TNG CTR ATTN ACOFS G3 PLNS & OPS DIV FT MCCLELLAN
10 COMDT USA INST FOR MIL ASSIST ATTN DOI FT BRAGG
1 COMDT USA CBR WPNS ORIENTATION COURSE ATTN DOI DUGWAY UTAH
1 COMDT USA FLD ARTY SCH ATTN DOI FT SILL
1 COMDT USA ARTY & MSL SCH ATTN EDUC SERVICES DIV FT SILL
1 COMDT USA ARTY & MSL SCH ATTN EDUC ADV FT SILL
1 COMDT USA TRANS SCH ATTN DIR OF DOC & LIT FT EUSTIS
1 COMDT USA TRANS SCH ATTN LIB FT EUSTIS
1 USA INST FOR MIL ASST ATTN EDUC ADV FT BRAGG
1 COMDT ARMY QM SCH OFC DIR OF NONRESID ACTVY ATTN TNG MEDIA DIV VA
1 COMDT USA ARTY & MSL SCH ATTN LIB FT SILL
1 CG USA SCH & TNG CTR ATTN ACOFS G3 FT GORDON
1 COMDT USA AD SCH ATTN AKBAAS-DL-FA FT BLISS
2 DIR BRGD + BN OPNS DEPT USAIS FT BENNING
1 DIR COMM ELEC USAIS FT BENNING
1 DIR ABN-AIR MOBILITY DEPT USAIS FT BENNING
1 CG US ARMY SIGNAL CTR & SCH ATTN SIGDTL-3 (CORBT II)
1 SECY OF ARMY, PENTAGON
1 DCS-PERS DA ATTN CHF C+S DIV
1 DIR OF PERS STUDIES & RSCH ODCSPER DA WASH DC
2 ACSFOR DA ATTN CHF TNG DIV WASH DC
1 CG USA MAT COMD ATTN AMCRD-TE
1 CHF OF ENGNRS DA ATTN ENGTE-T
1 HQ ARMY MAT COMD R+D DRCTE ATTN AMCRD-RC
1 US ARMY BEHAVIORAL SCI RES LAB WASH, D.C. ATTN: CRD-AR
1 DPO PERS MGT DEV OFC ATTN MOS SEC (NEW EQUIP) OPOMD
1 ARMY PROVOST MARSHAL GEN
1 DIR CIVIL AFFAIRS DRCTE ODCSOPS
1 OFC RESERVE COMPON DA
2 CG USA SEC AGCY ARL HALL STA ATTN AC OF S G1 VA
50 ADMIN DDC ATTN: TCA (HEALY) CAMERON STA ALEX., VA. 22314
1 CO US ARMY MED RES LAB FT KNOX
1 CHF OF R+D DA ATTN CHF TECH + INDSTR LIAISON OFC
2 CG ARMY MED R+D COMD ATTN MEDDH-SR
1 U S ARMY BEHAVIORAL SCI RES LAB WASH, D.C. ATTN CRD-AIC
1 COMDT USA CBT SURVEIL SCH & TNG CTR ATT ED ADV FT HUACHUCA
1 COMDT USA CBT SURVEIL SCH & TNG CTR ATTN ORG DOC & NEW EQUIP ARIZ
2 TNG + DEVEL DIV ODCS-PERS
1 COMDT USA CBT SURVEIL SCH & TNG CTR ATTN 1ST CBT TNG BDE ARIZ
1 CAREER MGT BR ATTN R DETIENNE CAMERON STA ALEX VA
1 PRES ARMY MAINT BD FT KNOX
1 DPTY PRES ARMY MAT COMD BD ABERDEEN PG
15 CG USCONARC ATTN ATIT-RO-RD FT MONROE
2 CG USCONARC ATTN LIB FT MONROE
1 CO ARMY CBT DEVEL COMD MILIT POLICE AGY FT GORDON
1 US ARMY ARCTIC TEST CTR R & D OFFICE SEATTLE
1 CHF USA AD HRU FT BLISS
1 CHF USA ARMOR HRU FT KNOX
1 CHF USA AVN HRU FT RUCKER
1 CHF USA INF HRU FT BENNING
1 CHF USA TNG CTR HRU PRES OF MONTEREY
2 CG 4TH ARMORED DIV ATTN DCSOT APO NY 09326
1 CO 3D ARMORED CAV REGT APO 09034 NY
1 CO 14TH ARMORED CAV REGT APO 09026 NY
2 CG ARMY ARMOR & ARTY FIRING CTR FT STEWART ATTN AC OF S TNG OFCR
10 CO 1ST BN 63RD ARMOR 1ST INF DIV ATTN S3 FT RILEY
1 CO 1ST BN 64TH ARMOR 3RD INF DIV ATTN S3 APO NY 09031
9 CO 2ND BN 68TH ARMOR 8TH INF DIV ATTN S3 APO NY 09034
1 CO COMPANY A 3D BN 32D ARMOR 3D ARMORED DIV APO NY
1 CO 3RD BN 37TH ARMOR 4TH ARMORED DIV ATTN S3 APO NY 09066
2 CO 2ND BN 34TH ARMOR 25TH INF DIV ATTN S3 APO SAN FRAN 96265
1 CALIF NG 40TH ARMORED DIV LOS ANGELES ATTN AC OF SG3
1 55TH COMD HQ DIV ARMY NG JACKSONVILLE FLA
1 CG HQ 27TH ARMORED DIV NY AIR NG SYRACUSE
1 TEXAS NG 49TH ARMORED DIV DALLAS
1 CG ARMY ARMOR CTR FT KNOX ATTN G3 AIBKGT
2 CG 1ST INF DIV ATTN ACOFS G3 APO SAN FRAN 96345
1 CG 3RD INF DIV ATTN ACOFS G3 APO NY 09036
3 CG 4TH INF DIV ATTN ACOFS G3 APO SAN FRAN 96262
1 CG 7TH INF DIV ATT ACOFS G2 APO SAN FRAN 96207
1 CG 8TH INF DIV ATTN ACOFS G2 APO NY 09111
1 CG 5TH INF DIV (MECH) & FT CARSON ATTN ACOFS G2 COLO
3 CG 82ND ABN INF DIV ATTN ACOFS G3 FT BRAGG
1 CO 197TH INF BRGD FT BENNING ATTN S3
1 CO 1ST BN (REINF) ATTN S3 FT MYER
7 CO 3RD BN 6TH INF REGT ATTN S3 APO NY 09742
1 CO 171ST INF BDE ATTN S3 APO SEATTLE 98731
3 CG 25TH INF DIV APO 96225 SAN FRAN
1 CO 2ND BN 15TH INF 3RD INF DIV ATTN S3 APO NY 09026
5 CG 24TH INF DIV ATTN ACOFS G3 FT RILEY
4 CO 1ST BN (MECH) 52ND INF 198TH INF BDE ATTN S3 APO SAN FRAN 96219
2 CO 4TH BN (MECH) 54TH INF ATTN S3 FT KNOX
1 CO USA PARTIC GP USN TNG DEVICE CTR FLA
2 CONSOL RES GP 7TH PSYOP GP APO 96249 SAN FRAN
2 DA OFC OF ASST CHF OF STAFF FOR COMM-ELCT ATTN CETS-6 WASH
1 CG MILIT DIST OF WASHINGTON
1 DIR ARMY LIB PENTAGON
1 STRATEGIC PLANNING GP CORPS OF ENGNR ARMY MAP SERV
1 CHF OF MILIT HIST DA ATTN GEN REF BR
1 CO USA 10TH SPEC FORCES GP FT DEVENS
1 CO 24TH ARTY GP (AD) ATTN S3 RI
1 CG 31ST ARTY BDE AD ATTN S3 PA
1 CO 49TH ARTY GP AD ATTN S3 FT LAWTON
2 HQS 4TH BN 59TH ARTY REGT ATTN S3 NORFOLK
1 CO 28TH ARTY GP AD ATTN S3 SELFRIDGE AFB
1 CO 52ND ARTY BDE AD ATTN S3 FT HANCOCK
1 HQS 45TH ARTY BDE AD ATTN S3 ARL HTS ILL
1 CG 101ST ABN DIV (AIRMOBILE) ATTN ACOFS G3 APO SAN FRAN 96383
1 CG 1ST CAV (AIRMOBILE) ATTN ACOFS G3 APO SAN FRAN 96383
1 US ARMY GEN EQUIP ATTN TECH LIB FT LEE
1 US ARMY TROPIC TEST CTR PO DRAWER 942 ATTN BEHAV SCIEN CZ
3 CG III CORPS & FT HOOD ATTN G3 SEC FT HOOD
30 CO 1ST ARMORED DIV ATTN G3 SEC FT HOOD

30	CG 2D ARMORED DIV ATTN G3 SEC FT HOOD
25	CO 13TH SUPT BGDE ATTN S3 SEC FT HOOD
10	CG USAFAC ATTN G3 SEC FT SILL
20	CO III CORPS ARTY ATTN G3 SEC FT SILL
20	CG USA AD CTR ATTN G3 SEC FT BLISS
3	CG ATTN G3 SEC FT POLK LA
1	BESO ARD OFC CHF OF R&D WASH DC
1	CHF OF R&D DA ATTN SCI INFO BR RSCH SPT DIV WASH DC
2	CINC US PACIFIC FLT FPO 96614 SAN FRAN
1	CINC US ATLANTIC FLT CODE 312A USN BASE NORFOLK
1	COR TNG COMMAND US PACIFIC FLT SAN DIEGO
5	TECH LIB PERS 11B BUR OF NAV PERS ARL ANNEX
3	DIR PERS RES DIV BUR OF NAV PERS
1	TECH LIB BUR OF SHIPS CODE 210L NAVY DEPT
1	HUMAN FACTORS BR PSYCHOL RES DIV ONR
1	ENGNR PSYCHOL BR ONR CODE 455 ATTN ASST HEAD WASH DC
3	CO + DIR NAV TNG DEVICE CTR ORLANDO ATTN TECH LIB
1	CO FLT ANTI-AIR WARFARE TNG SAN DIEGO
1	CO NUCLEAR WEAPONS TNG CTR PACIFIC U S NAV AIR STA SAN DIEGO
2	CO FLT TNG CTR NAV BASE NEWPORT
1	CO FLEET TNG CTR U S NAV STA SAN DIEGO
1	CLIN PSYCHOL MENTAL HYGIENE UNIT US NAV ACAD ANNAPOLIS
1	PRES NAV WAR COLL NEWPORT ATTN MAHAN LIB
2	CO + DIR ATLANTIC FLT ANTI-SUB WARFARE TACTICAL SCH NORFOLK
1	CO NUCLEAR WEAPONS TNG CTR ATLANTIC NAV AIR STA NORFOLK
2	CO FLT SONAR SCH KEY WEST
1	CO FLT ANTI-SUB WARFARE SCH SAN DIEGO
1	CHF OF NAV RES ATTN SPEC ASST FOR R & D
1	CHF OF NAV RES ATTN HEAD PERS + TNG BR CODE 458
1	CHF OF NAV RES ATTN HEAD GP PSYCHOL BR CODE 452
1	DIR US NAV RES LAB ATTN CODE 5120
1	DIR NAVAL RSCH ATTN LIB CODE 2029 (ONRL) WASH DC
1	CHF OF NAV AIR TNG TNG RES DEPT NAV AIR STA PENSACOLA
1	CO MED FLD RES LAB CAMP LEJEUNE
1	COR NAV MSL CTR POINT MUGU CALIF ATTN TECH LIB CODE 3022
1	DIR AEROSPACE CREW EQUIP LAB NAV AIR ENGNR CTR PA
1	OIC NAV PERS RES ACTVY SAN DIEGO
1	NAV NEUROPSYCHIAT RES UNIT SAN DIEGO
2	NAVAL MSL CTR (CODE 5342) PT MUGU CALIF
1	DIR PERS RES LAB NAV PERS PROGRAM SUPPORT ACTIVITY WASH NAV YD
:	NAV TNG PERS CTR NAV STA NAV YD ANNEX CODE 83 ATTN LIB WASH
1	COMDT MARINE CORPS HQ MARINE CORPS ATTN CODE AO-1B
1	HQ MARINE CORPS ATTN AX
1	DIR MARINE CORPS EDUC CTR MARINE CORPS SCH QUANTICO
1	DIR MARINE CORPS INST ATTN EVAL UNIT
1	CHF OF NAV OPNS OP-01P1
1	CHF OF NAVL OPS OP 037 WASH DC
1	CHF OF NAV OPNS OP-07T2
2	COMDT HQS 8TH NAV DIST ATTN EDUC ADV NEW ORLEANS
1	CHF OF NAV AIR TECH TNG NAV AIR STA MEMPHIS
1	DIR OPS EVAL GRP OFF OF CHF OF NAV OPS OP03EG
2	COMDT PTP COAST GUARD HQ
1	CHF OFCR PERS RES + REVIEW BR COAST GUARD HQ
1	CO US COAST GUARD TNG CTR GOVERNORS ISLAND NY
1	CO US COAST GUARD TNG CTR CAPE MAY NJ
1	CO US COAST GUARD TNG CTR & SUP CTR ALAMEDA CALIF
1	CO US COAST GUARD INST OKLA CITY OKLA
1	CO US COAST GUARD RES TNG CTR YORKTOWN VA
1	SUPT US COAST GUARD ACAD NEW LONDON CONN
1	OPNS ANLS OFC HQ STRATEGIC AIR COMD OFFUTT AFB
1	AIR TNG COMD RANDOLPH AFB ATTN ATFTM
1	TECH DIR TECH TNG DIV(HRD) AFHRL LOWRY AFB COLO
1	CHF SCI DIV DRCTE SCI + TECH DCS R+D HQ AIR FORCE AFRSTA
1	CHF OF PERS RES BR DRCTE OF CIVILIAN PERS DCS-PERS HQ AIR FORCE
1	CHF ANAL DIV (AFPDPL (R) DIR OF PERSONNEL PLANNING HQS USAF
1	HQ AFSC SCBB ANDREWS AFB
2	COR ELEC SYS DIV L G HANSCOM FLD ATTN ESRHA BEDFORD MASS
:	HQ SAMSO (SMSIR) AF UNIT POST OFC LA AFS CALIF
2	MILIT TNG CTR OPE LACKLAND AFB
2	AFHRL (HRT) WRIGHT-PATTERSON AFB
1	AMD AMRH BROOK AFB TEXAS
1	HQS ATC DCS/TECH TNG (ATTMS) RANDOLPH AFB
4	HQS ATC (ATCTD-M) RANDOLPH AFB TEXAS
1	COR ELEC SYS DIV LG HANSCOM FLD ATTN ESTI
1	DIR AIR U LIB MAXWELL AFB ATTN AUL3T-63-253
1	DIR OF LIB US AIR FORCE ACAD
1	COMDT OEF WPNS SYS MGT CTR AF INST OF TECH WRIGHT-PATTERSON AFB
1	COMDT ATTN LIB OEF WPNS SYS MGT CTR AF INST OF TECH WRIGHT-PAT.
1	6570TH PERS RES LAB PRA-4 AEROSPACE MED DIV LACKLAND AFB
1	TECH TNG CTR (LMTC/OP-I-L1) LOWRY AFB
2	AF HUMAN RESOURCES LAB HRHTO WRIGHT-PATTERSON AFB
2	CO HUMAN RESOURCES LAB BROOKS AFB
1	PSYCHOBIOLOGY PROG NATL SCI FOUND
1	DIR NATL SECUR AGY FT GEO G MEADE ATTN TDL
1	DIR NATL SECUR AGY FT GEO G MEADE ATTN DIR OF TNG
5	CIA ATTN OCR/ADD STANDARD DIST
1	SYS EVAL DIV RES DIRECTORATE DOD-DCD PENTAGON
1	DEPT OF STATE BUR OF INTEL + RES EXTERNAL RES STAFF
1	SCI INFO EXCH WASHINGTON
2	CHF MGT & GEN TNG DIV TR 200 FAA WASH DC
1	BUR OF RES & ENGR US POST OFC DEPT ATTN CHF HUMAN FACTORS BR
1	EDUC MEDIA BR OE DEPT OF HEW ATTN T D CLEMENS
1	OFC OF INTERNATL TNG PLANNING & EVAL BR AID WASH DC
1	DEPT OF TRANS FAA ACQ SEC HQ 610A WASH DC
1	SYS DEVEL CORP SANTA MONICA ATTN LIB
2	DUNLAP + ASSOC INC DARIEN ATTN LIB
2	RAC ATTN LIB MCLEAN VA
1	RAND CORP WASHINGTON ATTN LIB
1	DIR RAND CORP SANTA MONICA ATTN LIB
2	U OF SO CALIF ELEC PERS RES GP
1	COLUMBIA U ELEC RES LABS ATTN TECH EDITOR
1	MITRE CORP BEDFORD MASS ATTN LIB
2	SIMULATION ENGR CORP ATTN DIR OF ENGR FAIRFAX VA
2	U OF PGH LEARNING R+D CTR ATTN DIR
1	HUMAN SCI RES INC MCLEAN VA
2	TECH INFO CTR ENGNR DATA SERV N AMER AVN INC COLUMBUS O
1	CHRYSLER CORP MSL DIV DETROIT ATTN TECH INFO CTR
1	RAYTHEON SERV CO ATTN LIBN BURLINGTON MASS
2	EDUC & TNG CONSULTANTS ATTN L C SILVERN LA
1	GEN DYNAMICS POMONA DIV ATTN LIB DIV CALIF
2	MARQUARDT INDSTR PROD CO CUCAMONGA CALIF
1	OTIS ELEVATOR CO DIV ATTN LIB STAMFORD CONN
1	MGR BIOTECHNOLOGY AEROSPACE SYS DIV MS 8H-25 BOEING CO SEATTLE
2	CTR FOR RES IN SOCIAL SYS FLD OFC FT BRAGG
1	IDA RSCH & ENG SUPT DIV ARL VA
1	HUGHES AIRCRAFT COMPANY CULVER CITY CALIF
1	DIR CTR FOR RES ON LEARNING + TEACHING U OF MICH
1	EDITOR TNG RES ABSTR AMER SOC OF TNG DIRS U OF TENN
1	CTR FOR RES IN SOCIAL SYS AMER U
4	BRITISH EMBSY BRITISH DEF RES STAFF WASHINGTON
3	CANADIAN JOINT STAFF OFC OF DEF RES MEMBER WASHINGTON
3	CANADIAN ARMY STAFF WASHINGTON ATTN GSO2 TNG
3	ACS FOR INTEL FOREIGN LIAISON OFCR TO NORWEG MILIT ATTACHE
1	ARMY ATTACHE ROYAL SWEDISH EMBSY WASHINGTON
1	DEF RES MED LAB ONTARIO
3	AUSTRALIAN NAV ATTACHE EMBSY OF AUSTRALIA WASH DC
1	OFC OF AIR ATTACHE AUSTRALIAN EMBSY ATTN: T.A. NAVGN WASH, D.C.
2	AUSTRALIAN EMBSY OFC OF MILIT ATTACHE WASHINGTON
2	U OF SHEFFIELD DEPT OF PSYCHOL
1	MENNINGER FOUNDATION TOPEKA
1	AMER INST FOR RES SILVER SPRING
1	AMER INST FOR RES PGH ATTN LIBN
1	DIR PRIMATE LAB UNIV OF WIS MADISON
3	MATRIX CORP ALEXANDRIA ATTN TECH LIBN
1	AMER TEL+TEL CO NY
1	U OF GEORGIA DEPT OF PSYCHOL
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2	U OF KANSAS LIB PERIODICAL DEPT
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1	OHIO STATE U LIBS GIFT + EXCH DIV
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2	LIB OF CONGRESS CHF OF EXCH + GIFT DIV
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