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ABSTRACT

This document is designed for use as a resource and reference guide for Air Force instructional managers who are considering the adoption or expansion of computer-assisted instruction (CAI) at some future time, and also as a decision aid for an instructional manager currently involved in the CAI decision process. The contents are intended to be helpful where CAI systems are already available to the trainers, as well as in those cases in which the adoption of CAI requires new system acquisition. The handbook is divided into five sections: (1) Introduction and History of CAI; (2) Understanding CAI; (3) Critical Factors for Adopting CAI; (4) Decision Aids for Considering the Adoption of CAI; and (5) Resources. The section on decision aids includes worksheets for use in evaluating the need for CAI, identifying configurations most closely matched to instructional needs and practices, and estimating the feasibility of initiating CAI implementation. Resources listed include a glossary, an extensive bibliography, and lists of related associations and periodicals. (THC)

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AIR FORCE

HUMAN RESOURCES

COMPUTER-ASSISTED INSTRUCTION: DECISION HANDBOOK

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The Public Affairs Office has reviewed this report, and it is releasable to the National Technical Information Service, where it will be available to the general public, including foreign nationals.

This report has been reviewed and is approved for publication.

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This handbook has been written for two applications: first, as a resource and reference guide for Air Force instructional managers who are considering the adoption or expansion of computer-assisted instruction (CAI) at some future time and, second, as a decision aid for an instructional manager currently involved in the CAI decision process. The use of the handbook is appropriate for considering the implementation of CAI in a new course or in an existing course. Its contents are designed to be helpful where CAI systems are already available to the trainers, as well as in those cases in which the adoption of CAI requires new systems acquisition. A significant amount of knowledge about instruction and about Air Force instructional procedures and minimum experience with CAI are assumed. The workbook portion of the handbook presents specific tools, in the form of worksheets, for evaluating the need for CAI, for identifying configurations most closely matched to instructional needs and practices, and for estimating the feasibility of initiating CAI implementation.

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SUMMARY

The Computer-Assisted Instruction: Decision Handbook has been written for use as a resource and reference guide for Air Force instructional managers who are considering the adoption or expansion of computer-assisted instruction (CAI) at some future time and also as a decision aid for an instructional manager currently involved in the CAI decision process. The use of the handbook is appropriate for considering the implementation of CAI in a new course or in an existing course. Its contents are designed to be helpful where CAI systems are already available to the trainers, as well as in those cases in which the adoption of CAI requires new system acquisition. Field tests of the handbook were conducted at Sheppard and Keesler Air Force Bases late in 1983. The tests included a formative evaluation to improve the format and presentation of the handbook and an implementation analysis in order to estimate the resources required for appropriate application of the manual as a decision tool. The workbook portion of the handbook presents specific tools, in the form of worksheets, for evaluating the need for CAI, for identifying configurations most closely matched to instructional needs and practices, and for estimating the feasibility of initiating CAI implementation.

TABLE OF CONTENTS

I. INTRODUCTION AND HISTORY OF CAI

A. The Purpose of the Handbook

This handbook has been designed to provide information concerning the use of computer-assisted instruction (CAI), tradeoffs associated with the adoption of CAI, and procedural decision aids for selecting appropriate levels of CAI. In more specific terms, the handbook has the following two objectives:

1. To provide a general orientation to the nature of CAI and the applications that are possible with this form of instruction.

2. To provide Air Force training personnel who have to make decisions concerning the adoption of CAI with specific information and decision aids to help them specify the requirements for this instructional technology and to propose appropriate levels of its application.

The handbook should be especially helpful to those individuals who have little prior experience with CAI. For these individuals, as well as others, this handbook is designed to help its users comprehend the range of possibilities available in CAI. It is also designed to help the user apply CAI in a judicious manner as part of the overall instructional design and development of either an existing or new training course.

For the training managers or developers who have prior knowledge of and/or experience with CAI, this handbook provides a ready source of specific information necessary for the development of training plans and the determination of resources and data to secure a reasonable application of CAI within their training operations.

There has been no intention in the design of this handbook, however, to make it a single source of information on the full breadth of issues involved in applying CAI. It is important to distinguish the difference between the process leading to the decision to adopt a new technology and the processes necessary to implement the technology successfully. This handbook is designed to assist the user with the adoption decision process, and it discusses implementation issues only as they have relevance to that decision.

B. Organization of the Handbook

The handbook is arranged into five sections.

- Section I, Introduction and History of CAI, states the purpose of the handbook, gives a definition of CAI, delimits the context in which CAI is treated, and in an optional section, provides a brief history of CAI in Air Force Technical Training.

- Section II, Understanding CAI, provides a broad overview of the critical issues involved in making a decision about CAI. This section is meant to give the necessary background for understanding more fully the discussion of specific factors that will be detailed in Section III.

- Section III, Critical Factors for Adopting CAI, is a body of reference information on many of the major factors that should be considered in order to come to a preliminary decision about the use of CAI. These factors have been derived from the experience base of the last 2 decades of work in CAI. Section III is arranged so that it can be read straight through and also provides easy access to a particular issue when the decision aids in Section IV are used.

- Section IV, Decision Aids, provides a series of questions and flow charts to help in organizing the planning and decision process. These aids are provided in order to allow a reasonable assessment of the need for and the impact of using CAI, as well as providing a realistic assessment of the resources and activities required for a successful implementation.

- Finally, Section V, Resources, provides readily accessible information to use as a resource to seek further information beyond that which is provided in the handbook. The resources include a glossary of terms and acronyms.

Two general precautions apply when the handbook is being used. First, CAI is frequently and, for many applications, most efficiently utilized within a computer-based training system that includes management of student progress, training resources, testing, and instructional materials development and maintenance. (The treatment here is focused entirely on the interactive instructional mode called CAI and does not emphasize other important aspects of computer-based instruction.) Second, even with this limitation, CAI is still a complex topic; CAI itself and the decision to use it cannot be reduced to a set of simple truths. It is strongly urged that the information in this handbook be used as guidance tempered by the realities of a particular context and an appreciation for what is involved when introducing any kind of change into an organization.

As has been mentioned and will be again, CAI is not a panacea for all instructional or training problems. CAI is a powerful instructional tool--one that can be used to great advantage, as well as one that, if misused, can produce greater problems. The lessons of the past clearly point to the fact that the use of CAI requires commitment. It is hoped that this handbook will provide the necessary insight to the scope of the issues involved and the degree of commitment necessary in order to take full advantage of this powerful instructional technology.

C. A Brief History of CAI in Air Force Technical Training (optional)

The Air Force, along with the rest of the services in the Department of Defense, has been a pioneer in the research and development of CAI capabilities. Significant implementation projects for CAI have also occurred. Most notable of the CAI implementations that have occurred to date in the Air Force have been projects at the Chanute and Sheppard Technical Training Centers involving the PLATO computer-based instruction (CBI) system and the Advanced Instructional System (AIS) effort at Lowry AFB.

1. PLATO

PLATO (Programmed Logic for Automated Teaching Operations) was originally developed at the University of Illinois under the auspices of the National Science Foundation and the Department of Defense (DoD). The original research concepts for PLATO actually began in the late 1950s and resulted in several early versions; however, it was the version known as PLATO IV that ultimately became operational on a large scale at the University of Illinois. Initially, PLATO was purely a CAI system. In its present form, PLATO is now a commercially available CBI system which includes computer-managed instruction (CMI). PLATO is both the oldest and largest CBI system available. PLATO is primarily a centralized, time-shared system (these terms are more fully explained in Section III.D); however, there is also a stand-alone delivery capability version called MicroPLATO. Through funding provided by the Defense Advanced Research Projects Agency (DARPA), a Tri-Service evaluation of PLATO was initiated at the Chanute Technical Training Center (CTTC) at Chanute AFB. The CTTC was chosen because of its proximity to the University of Illinois. The evaluation project was conducted in three phases. The first phase lasted from July 1972 to June 1974 and involved extensive planning of the operational implementation and the acquisition of equipment. This phase was long because PLATO was still very much an experimental system in 1972, and significant effort was needed to work out a variety of logistical and technical problems.

Phase II of the PLATO evaluation project began in June 1974 and lasted until January 1976. Phase II was devoted to the development of CAI materials that became part of the new curriculum for the Special Purpose Vehicle Repairman courses at Chanute. This phase also included the validation of the developed material and their formal evaluation as to their capability to conduct instruction effectively.

Phase III of the PLATO project overlapped Phase II, beginning in October 1975 and concluding in September 1976. Phase III consisted of a series of seven experimental lessons to test the efficacy of CAI.

The evaluation that was performed on the Chanute PLATO project was extensive and is fully reported by Dallman, DeLeo, Main, and Gillman (1977). Summarized below are a few highlights of the findings of this report.

a. Instructional Effectiveness. Results indicated that PLATO-based instruction was as effective as the regular course of instruction and resulted in a 28 percent reduction in training time. As compared to programmed texts and workbooks, students were more attentive and stayed on task. The attentiveness to PLATO materials was comparable to that which students give to hands-on laboratory activities.

b. Cost Effectiveness. With the mainframe computer technology of the mid-1970s, the PLATO-based course was not as cost effective as a course based on programmed texts and conventional (i.e., printed) testing. The figures provided showed that the operational costs of the PLATO-based course were $87,500 higher than the estimated costs associated with programmed texts and workbooks. However, cost-avoidance savings due to the total combination of instructional system development (ISD) procedures, PLATO, and instructional material design was determined to be $180,000 a year. It was estimated that PLATO lessons were 10 percent more efficient than equivalent programmed texts.

c. Instructional Impact. Overall, the attitudes of students toward the PLATO-based instruction were more positive than the attitudes of their counterparts not using PLATO instruction. Initial positive attitudes of instructors toward PLATO declined over the period of the project and were attributable to dissatisfaction with a lesser direct role in the instructional process associated with PLATO. The PLATO project was able to operate within the existing Air Training Command regulations at the time; however, new and innovative training approaches potentially possible with PLATO were not attempted.

d. Instructional Development. Instructional development was carried out under the guidelines of ISD. The results of the PLATO project at CTTC revealed that the traditional concept of instructor/author was inadequate to cope with the demands of CAI development on a large scale. The recommendations of the evaluators was that a team approach to CAI development be used in the future.

e. Management. The PLATO-based instruction was managed under the administrative structure of group-pacing. Overall, the evaluators concluded that "drastic or unusual" management procedures were not required to manage PLATO; however, there were strong implications that the ultimate effectiveness and efficiency of PLATO-based instruction require extensive preplanning and a flexible attitude toward adopting nontraditional methods of training management. This finding is similar to recommendations made in a recent evaluation of successful implementations of self-paced instruction in general as reported in McCombs, Back, and West (1984).

In addition to the PLATO experience at CTTC, PLATO was also implemented and evaluated at Sheppard Technical Training Center, Texas, in the School of Health Care Sciences. The results of this implementation were reported by Deignan, Seager, Kimball, and Horowitz (1980) and by Steinkerchner, Deignan, Waters, and DeLeo (1977).

The results of the PLATO evaluation at Sheppard AFB pointed out the need for extensive preplanning activities to ensure that appropriate staff personnel are in place and that course instructional staff are trained prior to the implementation of CAI.

The Sheppard evaluation also provided cost data that reflect the use of a mainframe CAI system in which recurring communication costs are involved. For 1 full year (1975), a 20-terminal system incurred a cost of $50,000 for terminal leasing and $25,641 for communications back to the remotely located mainframe.

Instructionally, the Sheppard evaluation revealed that CAI had a demonstrable and significant impact on both the quality and effectiveness of instruction. CAI increased student performance as much as 18 percent over comparable areas of lecture-based instruction. CAI was at least 17 percent more efficient than programmed texts for low aptitude students; and for high aptitude students, time savings of 29 percent to 32 percent were achieved.

2. AIS

The Advanced Instructional System at Lowry Technical Training Center was undertaken by the Air Force to achieve two major goals: (a) to integrate a variety of known advanced instructional technologies in a system configuration that could support several operational training courses simultaneously and (b) to provide a powerful test bed for implementing and evaluating new instructional technology. AIS started as a contracted effort in 1973 and ran as such to the end of 1977. Its development continued from 1977 to approximately the middle of 1981, when the final portions of the original courses were no longer being supported by the research-funded AIS computer system. AIS is presently being used to support a variety of prototypic research and demonstration activities within the Air Force Systems Command as well as in operational commands such as the Tactical Air Command and the Strategic Air Command and in industrial applications.

Because AIS was designed to integrate a variety of instructional technologies, it was configured as a CBI (i.e., both CAI and CMI) system, with an emphasis on CMI. For a great portion of the time in which the AIS project was in effect, the major mode of instructional delivery was programmed texts. Toward the end of the project, a strong CAI capability was developed, and CAI materials were developed and implemented. The AIS is described by Lintz, Pennell, and Yasutake (1979; McManus (1979); and Montgomery and Judd (1979).

The results of the AIS program showed that CAI lessons resulted in reduced lesson failure rates. Programmed text lessons had an average failure rate of 23 percent whereas for the same lesson areas, CAI had a failure rate of only 6 percent (Lewis, Lovelace, Mahany, & Judd, 1980). In terms of efficiency, the CAI lessons in AIS averaged 11.2 percent less administration time than did similar lessons in a programmed text format.

An important aspect of the AIS experience with CAI is the fact that AIS CAI materials were developed using an authoring system (see Section III.D.2). The use of an authoring system can be contrasted to the use of an authoring language for the development of CAI (see Section II.E and Section III.D.2). The PLATO system as it was used in the earlier projects at Chanute AFB and Sheppard AFB used an authoring language. A recommendation that came out of both PLATO projects was that the development of CAI materials should be accomplished through the use of a development team consisting of both instructors and CAI authors. In the AIS system, the creation of an authoring system was designed to simplify the CAI authoring process such that instructors could be both subject-matter expert and author. Based on the AIS results, it is apparent that instructors can efficiently develop effective CAI materials, given the use of an effective authoring system which does not require computer programming expertise. The availability of CAI development tools such as authoring systems or authoring languages can help determine the amount of organizational impact the use of CAI will have.

3. Present CAI Activities

Several CAI efforts are in progress or are in the planning stage. The following project summaries illustrate the general level of ongoing CAI activities within the Air Force. The listing is not meant to be exhaustive.

ATS. This is the Advanced Training System. The purpose of this sytem is to provide organizations within Air Training Command (ATC) with a broad CAI and CMI capability to accomplish six training delivery tasks: information presentation, demonstration, drill-and-practice, evaluation, feedback, and remediation. Additionally, management capabilities will be provided to allow the appropriate and timely match of students, instructors, equipment, and instructional material resources. The management function will also provide the ability to track student progress and allow the evaluation of the adequacy of the instructional process.

Status. The test and operational phase is FY 1984. It is expected to become operational in FY 1985.

BLTMS. This is the Base Level Training Management System. The development of this system is also being supported by ATC. The purpose of this system is to provide a computer-based data collection and management capability that provides an interface between ATC technical courses and the Advanced Personnel Data System (APDS). BLTMS will also provide for course management and course documentation.

Status. BLTMS is an in-house effort of ATC.

TRIM. This is the Time Related Instructional Management system. This system provides CAI for Undergraduate Pilot Training, plus management and scheduling support for training flight activities.

Status. This system is operational at Goodfellow AFB, Texas.

PLATO. CAI as provided by the PLATO system is still being conducted at both Chanute AFB and Sheppard AFB.

Status. Ongoing

CDTS. This is the Computer-Directed Training System which originated at Keesler AFB in 1968. This CAI capability exists on the Honeywell H6000, Phase IV, base-level computer. The CAI is provided for the training of computer personnel (operators and programmers). Early 1970 experiments with CAI on the B-3500 demonstrated the effectiveness and efficiency of using a computer to provide on-the-job Base Level Military Personnel System (BLMPS) training using remote terminals. In early 1972, Hq USAF identified the World Wide Military Command and Control System (WWMCCS) as an area for similar training programs for computer operators, programmers, and system analysts. It was decided that a combination of resident Keesler courses and CAI lessons for use at operational WWMCCS sites would be used to satisfy user needs. The CDTS capability is available to data processing installations on an Air Force-wide basis.

Status. Operational

ISS. This is the Instructional Support System. This system is to provide a set of software modules for supporting CAI and CMI. The modularity will allow users to select just that level of CAI or CMI functionality which they need, thus avoiding an overly complex system. In addition, the software modules are to be transportable; that is, designed to operate on a variety of hardware from microcomputers to large mainframe computers. The ISS is a follow-on effort derived from the AIS demonstration system at Lowry AFB. The software will be written in Ada and targeted for TRIADS Library.

Status. In planning and initial development by the Air Force Human Resources Laboratory.

4. Other DoD CAI Efforts

All three services have conducted research and development (R&D) in CAI over the last 2 decades. The body of information available from this R&D is voluminous. Background information on CAI based on DoD work in the area is available from the Defense Technical Information Center (DTIC) and/or the National Technical Information Service (NTIS). Of interest are the following major efforts presently existing within the DoD community.

TRIADS.(TM) This is a joint service effort that involves the planning and development of a family of hardware and software capabilities which have sufficient flexibility to support a large variety of CAI and CMI requirements. The TRIADS Joint Service Committee consists of representatives from the Army

Research Institute (ARI), Air Force Human Resources Laboratory (AFHRL), Navy Personnel Research and Development Center (NPRDC), and Naval Training Equipment Center (NTEC).

The hardware for TRIADS is to feature modularity and interdevice compatibility. The software is to be based on the new DoD language Ada and is to be machine independent and user friendly. Five levels of capability are to be provided within the TRIADS concept: Level 0, Limited Function Portables; Level 1, Single User Instructional Device; Level 2, Single User Workstation; Level 3, Multi-User Workstation; Level 4, Artificial Intelligence Compatible Workstation; and Level 5, Multi-User Mainframe. The TRIADS also incorporates a software library of instructional support and development tools plus courseware in broadly applicable content areas. ISS and CBESS represent the type of software which will be included in the TRIADS Library.

CBESS. This is the Computer-Based Educational Software System (CBESS). It involves the development of a software library based on the use of a common, machine-independent software language. The candidate languages being considered are Pascal, C, and Ada. The software for several existing Navy programs are to be converted into the chosen language. The following programs are to be converted:

- CASIMS: Computer-Assisted Instruction Study Management System
- EEMT: Electronic Equipment Maintenance Trainer
- The Computer-Based Tactical Memorization Training System
- Language Skills Computer-Assisted Instruction

TPSS. This acronym refers to a computer-based system of instruction and job performance aids developed for the Air Force Systems Command (AFSC). The Denver Research Institute has augmented vendor-supplied hardware and software to implement a "Training and Performance Support System" (TPSS) for Air Force personnel assigned to System Program Offices (SPOs).

The system was designed for novice and less experienced acquisition managers and provides access to an individually tailored curriculum on an "as-required" basis. Each lesson topic is complemented by a task-oriented data base which provides job performance aids in the form of policy, lessons learned, procedures and technical background information. These aids are accessible from the work environments.

An instructional model designed for adult learners is employed in TPSS and formative evaluation of the system concept and implementation will begin at the Electronics Systems Division during October 1983, prior to deployment in other AFSC Divisions.

D. Computer-Assisted Instruction in Perspective: A Definition

The application of computer technology to the instructional process is by no means a recent development, although with the advent of lower-cost computer hardware, the feasibility and attractiveness of this technological application have increased rapidly. Earliest research applications occurred in the 1950s, followed by significant practical applications using large mainframe computers occurring in the mid and late 1960s. One such early application that was developed at the University of Illinois during the 1960s and has since evolved and matured into one of the major computer-based instructional systems is the PLATO system. Several computer-based instructional systems are now available and offer a wide range in both system cost and capabilities. Thus, the application of computers to the instructional process has a background of over 2 decades of research and application.

A general historical background on computer applications to instruction is available from the literature listed in the bibliography (Section V.C). This literature provides a wide range of descriptive terminology and corresponding acronyms. However, the most often described application of computers to instruction is referred to as **computer-assisted instruction** (CAI). It is this particular application and its variations that are the subjects of this handbook.

Computer-assisted instruction is defined as follows:

COMPUTER-ASSISTED INSTRUCTION (CAI) IS THE USE OF THE COMMUNICATION AND STORAGE CAPABILITIES OF A COMPUTER TO PROVIDE THE DIRECT PRESENTATION OF INSTRUCTIONAL MATERIALS AND/OR PROVISION OF PRACTICE TO THE LEARNER.

1. Variations in CAI

The definitio given is general and does not reflect the range of specific instructional strategies or types of instruction that can be included under the umbrella of CAI. A complete discussion of these specific strategies can be found in Section II of this handbook. Briefly, however, the range of CAI applications includes those which are conventionally found in most educational and instructional situations. These would include straight expository presentations typical of a lecture format or a textbook, as well as interrogative presentations typical of classroom discussions and informal quizzes. Additionally, CAI offers unique capabilities associated with the dynamic communication and presentation qualities of the computer medium. It is these latter qualities which are of special value in the form of highly interactive tutorial- and simulation-type presentations. However, as in any complex human endeavor such as instruction, no single form or type of technological approach is universally applicable. As mentioned, the purpose of this handbook is to permit judicious judgments about the adequacy of CAI as an instructional technology and method and not to represent CAI as a panacea for all instructional and/or organizational problems.

In addition to the terminology of CAI, other terminology and forms of computer applications will be encountered in the realm of instruction. Rather than CAI, the term **computer-assisted learning** (CAL) may be found; this term has evolved primarily from work in the United Kingdom. As will be discussed shortly, early CAI work was heavily influenced by research and applications of programmed instruction and its primary medium—the programmed text. Programmed instruction has been primarily based on a psychological theory of learning called behaviorism and has found extensive use in areas of instruction concerned with training. Training, as contrasted to education, is typically characterized by well-defined tasks and specific, definable outcomes. Education, on the other hand, is more often characterized by general goals and outcomes geared to prepare an individual for a variety of potential activities. Generally speaking, CAL is a term which has come to be preferred by certain educators to reflect an emphasis on the general learning process associated with education and to reflect also an emphasis or concern for the activities of the learner. This contrast can be represented in noncomputer terms as the difference between learner-based activities versus instructor- or teacher-based activities.

Another term that will be used more in the future is **intelligent computer-assisted instruction** (ICAI). ICAI is a form of CAI which applies principles from the field of artificial intelligence to achieve a lesson structure which permits a greater degree of individualization. Additional information on ICAI is provided in Section II D.6. The development of ICAI reflects a characteristic of the development of most new technology--its initial widespread application tends to be evolutionary As a consequence, its initial use tended to reflect the application of concepts from earlier technologies that preceded it, just as early television shows reflected the techniques of the live theatre or of radio broadcasting before people became experienced enough to capitalize on the unique features of the new TV technology. As is frequently the case with pioneers, early workers in CAI had typically high expectations for the new technology. However, these expectations often exceeded the capabilities of the computer hardware and software available. As both hardware and software capabilities have improved, the original high expectations are becoming achievable.

In CAI, the original expectation was that the computer would serve as an exemplary teacher, carrying on a rich dialogue with the student. In fact, instructional programs implemented in the early years of CAI were often automated versions of printed text materials, such as programmed texts, or film-based materials, such as instructional filmstrips. As more experience was gained and computer hardware and software capabilities decreased in cost, applications of CAI have improved in their ability to take advantage of the features of the computer communications medium. ICAI is a term that is now applied to CAI applications which do in fact represent a quality dialogue between the learner and the computer and which meet the original high expectations of the pioneers in CAI. A characteristic of ICAI is that the dialogue or the flow of the lesson is not predetermined. Unlike typical CAI tutorials in which the author anticipates possible student responses and provides a certain set sequence of instruction for each response, an ICAI lesson is characterized by its ability to adapt the lesson flow on the basis of its own decision model rather than a limited set of predetermined possibilities. Such a capability has been achieved by applying knowledge from the area of research known as **artificial intelligence**.

The discussion so far emphasizes the perspective that the term CAI is broad in meaning. Those who use this handbook to help understand how and where to apply CAI, should keep in mind the wide variations of CAI that are now possible and those that will soon become possible. CAI is really a continuum of applications ranging from the simple presentation of information to the rich dialogue capabilities of ICAI. When vendors, consultants, and other professionals provide requested information, these people must carefully specify the CAI application to which they are referring.

Finally, the computer is increasingly being used in combination with other forms of technology. Thus, it is likely that reference will be made to such terms as **computer-assisted video instruction** (CAVI)--the application of computer technology with either video disc or video tape technology, and **computer-assisted instructional simulation** (CAIS)--the combination of CAI with the simulation technology of a particular environment. As the number of applications of CAI increase, further differentiation can be expected in the terminology used.

2. CAI and Other Instructional Technology

CAI refers strictly to the delivery of instruction and/or provision for practice. CAI in all of its present and future variations is simply another medium of instructional delivery. Other media of instructional delivery include the human instructor, student peers, television, the various film-based media, etc. To decide on the adoption of CAI for an entire course or even for any part of a course requires balancing the costs and benefits of CAI against these other forms of delivery media. A more detailed treatment of the limitations and potentials of CAI are treated in Section II of this handbook.

Each type of delivery medium has its own unique qualities which make it advantageous to use in certain situations. Although the focus of this handbook is on CAI, it is important to be able to contrast its strengths and limitations with the special qualities of other delivery media. Four broad categories of alternate delivery media to CAI are discussed briefly below.

a. The Instructor. The human instructor still provides the most adaptable and flexible form of instructional delivery. In most instructional settings, the instructor is a critical resource. Thus, administrative structures (e.g., group instruction) are established to make this delivery resource available to the largest feasible number of students. Changes in the content to be delivered are easily implemented (e.g., simple annotation of an instructor's lesson plans). This delivery resource has time limitations. Students cannot access information at will. This delivery resource also lacks reliability in that different instructors can provide inconsistent instruction on the same objective. However, instructor delivery, if time permits, can be very responsive to student needs and can provide students with an overall model of behavior to be emulated. The instructor is irreplaceable in conveying appropriate attitudes and in supporting and providing long-term motivation for students.

b. Print Media. This delivery resource is generally unconstrained by time. Access to instruction in print form can occur at any time and at any place. Of all delivery media, print is the least expensive, especially if large numbers of students are to be reached. Printed instructional materials can be easily personalized by a student through the addition of notes or marking techniques such as underlining and is the most familiar of all training media. However, the print media as a delivery resource is constrained by its lack of adaptability to student needs. Even printed instruction in the form of programmed texts is limited in its ability to provide predetermined alternative instructional messages based on student need or particular errors made during learning. The student typically cannot interact with print materials. Modification of printed instructional materials can be both time consuming and difficult. Partial changes to a document require extensive administrative procedures to ensure that all copies distributed over a range of locations are updated. Major changes which require reprinting of a set of materials can become costly if such changes occur frequently.

c. Film Media. This category includes both still media, such as photographs, slides, microfiche, etc., and motion media, such as movie film. Also included in this category, for convenience, are video tape and video disc. The film media are generally expensive and can be limited by the special equipment required for both production and utilization (projectors, tape players, etc.). Good film or video-type instructional materials can provide a very concise and motivating message to students. Also, this form of instructional delivery can represent time-based events in the real world not easily conveyed in either print or speech alone. Film-based media by themselves (this excludes film-tape/computer hybrids) are not interactive and do not adapt to individual student needs. Film-/tape-based instructional materials are very expensive to produce and reproduce. For these media there is no difference between a simple modification and a major change since both require a complete revision and reproduction of the instructional materials. The time to revise is usually very long as compared to either print or instructor-delivered materials. Film/tape materials can be used to convey attitudes and provide motivation on a student population-level basis, but such materials cannot respond to individual needs as an instructor can.

d. Audio Media. This delivery media can provide stand-alone instruction, but is usually used in conjunction with the preceding delivery media. As such, it can enhance student learning by providing an alternate processing channel—students can both read (see) and hear information. Audio media are many times a preferable delivery category for students who have difficulty reading. The use of audio for these students can be slowly phased out as students improve their reading skills. Costs to make and reproduce audio tapes are relatively low and audio tapes, if used appropriately in conjunction with other delivery media, including CAI, can meet individual student learning needs.

e. Adjunct Support for CAI. Both print and film-/tape-based media can be used independently but often are used in an auxiliary mode to the instructor. As mentioned, tape-based materials are frequently being used as an auxiliary presentation mode with the computer. In both cases, the instructor and the computer provide a level of interactivity and responsiveness to individual needs that the other media do not provide by themselves. CAI should not be excluded as an auxiliary support medium for the instructor. Large-screen TV projectors and small microcomputers with good color graphics can be combined to provide a potent support mechansim for group presentations. Although a major advantage of CAI is its capability to provide individualized instruction in an efficient and effective manner, group uses of CAI should not be excluded from possible applications.

This is a good point at which to discuss another use of the computer in support of the instructional process. In addition to helping provide for the delivery of instruction, the computer can be used to support the management of instruction. This instructional use of the computer is referred to as computer-managed instruction (CMI). CMI is distinct from CAI and provides specific capabilities for testing, scheduling, allocating resources, collecting student data, and providing status reports. These are the major functional areas of CMI, and like CAI, CMI applications range widely in their emphasis on particular features and the amount of capability that they provide. A useful way to think of the relationship between CAI and CMI is to see CAI as one of many possible instructional delivery resources which a CMI system could support and manage. Thus, it is possible to have a CMI system which simply manages only non-CAI instructional delivery media. However, when a CMI system is combined with the significant use of CAI, the combination of these two technologies is commonly referred to as CBI--computer-based instruction.

In terms of the type of support provided, CAI and CMI have different quantitative relationships to the student population. As will be emphasized throughout this handbook, CAI is an individualized instructional delivery medium; thus, it has a one-to-one relationship between the delivery hardware (i.e., computer terminal) needed and the student. CMI, on the other hand, has a one-to-many relationship between its input and output hardware (i.e., the CMI work station) and the student that it supports. What this means is that for CMI the student population can increase within a certain range without requiring more CMI equipment. For CAI, increases in student population will typically require the addition of more CAI hardware.

With the exception of the instructor, CAI is the only instructional delivery medium which is truly interactive and which is flexible enough to change the nature of the instructional message delivered on the basis of its ongoing use by the learner. Whereas more traditional forms of instructional delivery media (e.g., overheads, filmstrips, movies) are best used in an adjunct mode to the basic instructor-led lecture or recitation, CAI can be used in a primary and independent way to provide instructional delivery. Thus, in those situations in which organizational constraints might perhaps limit the availability of instructors or where instructor-led activities need to be complemented by more intensive individualized work by the student, CAI offers a substantially greater range of capabilities than do other instructional media. This relationship of CAI to organizational and instructional needs is treated further in Section II.F of the handbook.

3. CAI's Relation to Instructional System Development (ISD)

ISD, to quote AFM 50-2, "(is) . . . a systematic procedure for assuring application of instructional technology to course planning and development." Further, AFM 50-2 states, "The intent of ISD is to develop QUALITY training at the least cost." ISD is above all a management process, although early applications of it have become closely associated with the concepts of programmed instruction and self-pacing. This association has often created the impression that the concern of ISD has been on improving the efficiency of instruction even to the detriment of the quality of instruction. This handbook stresses the fact that self-pacing is merely one administrative technique for providing instruction to students, in the same way that group-pacing is an administrative technique for providing instruction. A substantial body of evidence has accrued to show that self-pacing as an administrative form of scheduling and providing instruction does produce significant time savings as compared to group-paced instruction (McCombs, Back, & West, 1984). However, just as the quality of instruction in group-paced courses is highly or even primarily dependent on the quality of the instructional delivery provided by instructors, the quality of instruction in self-paced courses or segments of a course is equally dependent on the instructional delivery medium used and on the quality of the instruction delivered.

The Air Force's five-phase process of ISD (analyze, design, develop, implement, control) is meant to ensure that appropriate training requirements that fulfill the operational requirements for trained personnel are established. When training requirements have been established and translated into appropriate training and instructional objectives, then step four of the ISD model provides for the planning of how these objectives can best be achieved. Part of this planning process is to select the appropriate medium and technique of instructional delivery. If certain instructional objectives might best be achieved through an individualized, self-paced form of instruction, then the decision to adopt CAI as an instructional delivery medium becomes relevant. CAI allows a range of alternative instructional strategies to be implemented which exceeds previous self-paced and individualized media such as programmed texts. In this regard, the availability of CAI can provide a powerful instructional resource to meet certain types of training requirements. Within the decision processes required by the Air Force ISD model, this handbook should provide the information needed to make the determinations and tradeoffs necessary to decide whether or not CAI should be adopted in a specific training situation.

II. UNDERSTANDING CAI

A. Why Use a Computer for Instruction?

A good question: Why would anyone want to use a computer as an instructional delivery medium? Consider some of the accommodations and changes that will be required in the training environment. First, the training environment and/or part of the course must be flexible enough to accommodate some individualized and self-paced instruction, for these are the two major assumptions upon which most forms of CAI are predicated. Next, there has to be a commitment for hardware acquisition (purchased or leased) and maintenance. It is especially important that there is a commitment to acquire the CAI course materials—whether the plan is to purchase "canned" lessons or to develop them in-house. During transition, lesson content validity (teaching what was intended) and design validity (material presented appropriately) must be considered. Consideration must also be given to updating materials and the resources required for this. Finally, instructor roles in relationship to self-paced instruction have to be planned for and implemented. In light of these commitments, the use of a computer as an instructional medium must be justified.

On the instructional side, the computer delivery of instruction and practice can provide students with a level of interactive, individualized instruction that is difficult, if not impossible, to attain with other media. Individualized instruction was the premise on which CAI was originally conceptualized and developed. CAI can require the student to be an active participant in the learning process. These attributes are not guaranteed in group-paced, lecture-type instruction, nor are they maximized in paper-and-pencil programmed instruction. It should be noted that CAI does not always take advantage of its potential and should be viewed as a tool that makes it possible to reach the goal of individualization.

Institutionally, the computer allows for flexible instructional planning. In addition to the delivery of course materials (mainline instruction), a robust courseware library can provide the following: prerequisites in instruction, special remediation including homework assignments, extensive or additional practice through drill or simulation, enrichment/elaboration, or basic skills training. CAI is available on demand. It can permit flexible scheduling of students and classes if an adequate number of delivery stations or terminals is available. For example, students may receive elaboration or remediation "after hours," at their own or the instructor's discretion. Portions of several courses that have a common core of instruction might benefit in terms of costs and standardization if the common elements were available via CAI. Another institutional advantage is standardization of training; i.e., material and evaluation criteria are standardized. Lastly, CAI has been shown in many studies across many disciplines to significantly reduce training time to criterion mastery (Kulik, Kulik, & Cohen, 1980).

B. What Are the Limitations of CAI?

One of CAI's greatest limitations is not a characteristic of this tool, but rather, of how the tool may be misused. As with any medium, the benefits of CAI are jeopardized by poorly planned development and implementation, e.g., limited development time, an inexperienced development team, or lack of planning for the development of off-line training materials or activities should the computer become unavailable to students. The use of CAI does require special support; that support must be planned for well in advance. As a medium, CAI can help to develop and deliver highly interactive, individualized courseware instruction. Bad courseware does not mean CAI is bad. For example, CAI has, over the years, been the recipient of "bad press" because it has frequently been inappropriately (and expensively) used only to deliver automated, programmed text. It can do much more. The capabilities of the CAI medium need to be brought out and exploited in the courseware-developed capabilities, such as branching, dynamic graphics, adaptive drill-and-practice, simulation, and gaming. So, if CAI is chosen because its special characteristics best fit the requirements of a course, it must be remembered that effective use of those characteristics requires special commitments to their development and support.

After having considered underutilization of CAI's potential in the development of courseware, the next interest is in concerns and potential limitations regarding institutional impacts of the delivery of CAI. CAI creates an individualized, interactive environment that can limit human contact and social interaction during the time a student is using the system. This may or may not be troublesome, depending on the specifics of the application and the trainees for whom it is intended. For example, if a course trains recruits new to the Air Force, perhaps one of the objectives is indoctrination in values and attitudes, such as professional ethics. If recruits interact solely with the computer, such objectives may not be easily reached. In this example, perhaps CAI could be used effectively to reach the instructional goals by providing basic skills instruction and practice with solving technical problems via drill-and-practice or simulations. However, the instructional staff itself would provide the intense interpersonal interaction needed to build healthy attitudes and values.

Up to this point in the discussion of limitations, the potential limitations of the medium and its use have been related. Another type of potential limitation is CAI's impact on the needs and role of instructors. For the most part, instructional staff members have been trained in traditional instructor-centered classroom techniques; that is, lecture, discussion, and demonstration. For many, having the computer provide part of the instructing role appears to constitute a demotion of the instructor's role to that of "paper pusher" or "babysitter." This reaction and related resistance are, perhaps, understandable because instructors generally believe that they have the expertise, based on experience, necessary to provide trainees with the context and meaning for their training. Instructor needs must be accommodated.

The role of the instructor can be very different in a training environment that uses CAI, but it is not necessary to view that changing role negatively. In fact, the change in instructor role is more a matter of emphasis. In the individualized environment, the instructor's role focuses on each individual student's learning needs and on integrating CAI with appropriate individual and group learning activities. The tasks of counselor, remediator, diagnostician, and evaluator, as well as learning manager and monitor, are all part of the new role (McCombs & Dobrovolny, 1980). It has been essential in most successful implementations to train instructors in their new roles, encouraging a creative and flexible approach to the more flexible training environment. Many factors go into successful projects, but especially important is instructor training and early inclusion of the instructor staff in project planning and development. To the degree that CAI is seen as a nonintegrated technology, separate from the mainstream training environment, the implementation will be less than optimal, and its results possibly detrimental to the entire training mission.

There are two additional potential drawbacks. The first is another potential misuse of the medium; that is, CAI should be (but is often not) seen as one medium in the constellation of media that may meet an instructional need. CAI may be useful for some objectives but not others in a course. The choice of CAI should be driven by instructional need for that medium's unique capabilities. The second drawback is the typical length of time required to prepare lessons and validate them. Although recent advances in authoring of CAI are impressive, if only very limited time is available to develop a course, CAI will have a very restricted role.

To summarize, CAI in and of itself does not guarantee quality instruction. Quality lies in the content and in design of the courseware that takes advantage of the medium's potential for interactivity. Also, the delivery of interactive instruction affects instructor roles, and appropriate adjustments in these roles must be made. CAI cannot easily substitute for direct human contact in courses in which the goals are to teach values and ethics. Finally, CAI should be chosen based on its potential for best meeting instructional or institutional needs, and ample development time is essential.

C. What Are the Unique Potential Benefits of CAI?

With the exception of a one-on-one tutor, CAI has the potential to deliver the most responsive and individualized instruction of any instructional alternative. CAI's unique characteristic is its interactivity. In all of the different modes of CAI (including tutorial, drill-and-practice, gaming, and simulation), interactivity plays a central role. When a student finishes a well-designed and well-implemented CAI lesson, it is apparent that the student has actively attended to the material each step of the way. By use of simple instructional games or clever graphics, CAI can also contribute to high levels of student motivation.

Consider a tutorial situation. In lectures, a student can doze off. In programmed texts, the student can peek ahead. But in a CAI tutorial, the student must attend to each point of interaction in order to complete the lesson.

Moreover, CAI can adjust the quality and complexity of these interactions through lesson branching techniques. For example, a wrong answer to an embedded question might be met with a deeper explanation, with its own opportunities for interaction. Students can also be branched to earlier sections of the lesson for review or can be given more condensed or expanded versions of the lesson, based on pretest results.

Let us consider the role of interactivity in practice. Of course a student cannot complete a homework assignment by dozing off or peeking at the answers. Often the work as well as the solution must be shown to prove the practice is honest. But most people have faced a blank page when even an approach to a solution escaped them. The interaction necessary to arrive at even an approach to the solution awaits the next class, or help from the instructor. With CAI, practice can be interactive immediately for all students individually--with appropriate prompts and cues for guiding students to problem solutions--as they solve problems and work examples. Moreover, repetitive drill, which requires more self-discipline than many students have, can be provided and enforced with CAI. Finally, dynamic simulations, approaching sufficient fidelity to substitute for actual equipment, can be delivered only through the computer-based medium.

Some unique potential organizational benefits as well as instructional benefits are associated with CAI. Included are the issues of cost effectiveness and reduced training time. Further in this section is a subsection entitled "Will CAI be Cost Effective?" that will describe training benefits and cost tradeoffs. At this point it is relevant to describe briefly several aspects of CAI that have unique organizational benefits.

1. The quality of lessons, content as well as instructional strategy, can be standardized so that all students across time can get an equally good lesson. At a time when an experienced and trained instructor staff is becoming a scarce resource, this could be particularly important. Using the experienced instructors in the CAI design and development process is an economical use of their expertise and helps assure high quality.

2. The lessons themselves can be more quickly and economically updated if the lessons are systematically developed and modularized (see subsection E., "How is CAI developed") than can hard copy that has to be reprinted.

3. Automatic data collection that is usually integrated within a CAI lesson is another benefit of this medium. Reports generated from CAI lesson data that have been automatically collected can allow instructors to see how students are progressing and where students are having difficulty, and can be used to evaluate the CAI itself.

4. Portions of courses may share the same instructional content with several other courses, i.e., basic

electronics, auto repair, or troubleshooting. By providing standard courseware for shared-core courses, economy may be an outcome in development time, instructor delivery time, and potentially, in student time.

In summary, the selection of CAI as a delivery medium entails a careful consideration of the requirements, benefits, and limitations of CAI (see Table II-1).

D. What Are Basic Types of CAI Applications?

Over the last 2 decades, CAI has evolved to take advantage of increasingly sophisticated hardware and software, as well as advances in cognitive theory and instructional design. The basic functions that CAI serves, however, have remained the same: the presentation of information, the demonstration of the applications of skills and knowledge through examples, and opportunity for practice. For information presentation and demonstration, the ways in which these basic functions are accomplished range from simple linear information presentation to complex, intelligent CAI; for practice, they range from nonadaptive, simple problem sets to sophisticated task simulations.

Described and defined below are the basic strategies or methods used in CAI. These descriptions are amplified in Section V.D, which contains screen print examples of the methods and strategies.

1. Informational

Information can act as part of the instructional process without being specifically instructional. For example, during a group-paced lecture, it may be important to demonstrate or elaborate on an instructional point. The instructor can use a microcomputer and large-screen monitor as a kind of electronic blackboard or dynamic slide to show a graphical representation of a process or set of procedures. Factual information can be available as an addition or adjunct to the instruction, either under lesson control as a prompt to the student or under learner control as an optional HELP. In the course of a practice or problem-solving session, the student may require factual information in order to work toward a problem's solution; e.g., the problem may require that the student refer to a manufacturer's specifications. In this instance, a data base of relevant information such as regulations, specifications, or schematics could be available to the student. Informational CAI can be used as a dynamic tool, with information such as helpful hints or lessons learned added by instructors at any time.

Table II-1

Summary of Section II A, B, and C:
Requirements, Limitations, and Potential Benefits of CAI

Requirements for CAI	Limitations of CAI	Potential Benefits of CAI
		<u>Instructional</u>
Flexibility of course and training environment to accommodate self-pacing and individual instruction	Requirements for special personnel and resource support	Highly interactive, individualized instruction
Commitment for hardware acquisition and maintenance	Potential limiting of human contact and social interaction	Instructional and scheduling flexibility
Commitment for materials development/acquisition and updating	Potential for inappropriate application and implementation	Consistency of training, material, and evaluation criteria
Planned changes in instructor roles and role training	Unable to substitute for adequate planning, courseware development, and instructor/staff preparation	Higher degree of student activity, attention, and motivation
		<u>Organizational</u>
		Potential cost effectiveness and time savings
		Automatic data collection
		Capacity for quick and inexpensive update of materials and tests

2. Drill-and-Practice

Applying what has been learned through practice problems is a very important and essential part of the learning process. Practice not only verifies that the learner can actively use concepts, skills, and procedures which have been taught, it also affords the learner the opportunity to practice transferring and generalizing concepts and strategies to problems dissimilar from examples demonstrated. Practice provides opportunity for enhanced learning through provision for multiple encoding; the more ways one stores information, the more ways one can get to the information learned, and the better that information will be remembered.

The rather stereotyped view of computer-assisted drill-and-practice is exemplified by problem sets of simple math fact problems or sets of multiple-choice questions that quiz the learner about factual information. However, drill-and-practice can be a good deal more sophisticated. For example, even with math facts, the computer can keep track of the facts that are most difficult for each student and adapt the questions to reflect the need for additional practice in particular areas. The drill-and-practice technique is commonly used to quiz students on nomenclature (e.g., parts of anatomy, parts of a vehicle). It is also used to drill students on parts of a process; e.g., what do you do after you have installed the condensor or what do you do after you have secured the patient on a stretcher, etc.? Often, instruction may be delivered by instructors or another medium while the computer will be used for the drill-and-practice. Thus, drill-and-practice is often provided at the subtask level.

3. Tutorial

In tutorial CAI, the computer presents instruction. Frames of text and graphics are typically interspersed with embedded questions such as constructed answer, true/false, multiple-choice, or matching questions. Immediate feedback messages and schemes (including branching to remediation or elaboration segments) are, in good measure, what makes the lesson a tutoring experience.

One of the original intents of CAI was to provide for a Socratic-type dialogue between the learner and the computer. To be truly Socratic, tutorial CAI must be able to adapt to the nature of the student-computer interactions, to diagnose faulty reasoning or misunderstandings, and to guide the student toward the objective. To be truly a dialogue, there must be provision for the student to ask the computer questions as well as for the computer to pose questions to the student. A dialogue is a two-way communication.

The history of tutorial CAI has, unfortunately, in many instances not lived up to the original expectations of educators and trainers. For the most part, tutorials have not been dialogues; they have been linear, nonadaptive programs. Designers and programmers have had to "fit" the embedded questions and responses and branching options into sets of probable student responses. The results of this design approach can range from quite adequate to woefully inadequate, depending on careful planning of the designer and on the homogeneity of the student population and their probable responses. Designing elaborate strategies for learner and program control over the flow of the lesson has proven to be very time consuming and difficult, especially for designers new to the potentials of the medium, and for subject-matter experts with little training or experience in learning theory, individual differences, etc. The result has been a lot of "tutorials" that are linear, not highly interactive, nonadaptive, and that take a view of the learner as a passive recipient of information. The term "page-turner" has often been used to describe this type of CAI, a kind of automated programmed text. For the most part, very little is to be gained from using the medium in this manner. Because tutorials have not, for the most part, been developed along the lines which were originally intended, they have gotten a reputation as being an expensive and often frustrating or boring mode of instructional delivery. Some high-quality tutorial CAI has been developed over the years and exemplars can be found in most commercially available CAI systems. Additionally, systematic methods for developing tutorials that will help authors turn out instructionally sound materials have been designed and documented recently.

4. Simulation

Simulation as a form of CAI gives a student an opportunity to practice whole procedures and tasks or to solve problems in life-like or job-like sequences. Typically there is no single correct sequence of action in the tasks or problems simulated. The state of the simulation depends on what the student has done up to a given point in the task or problem, and what must be done past that point is determined on the basis of that performance.

For example, consider a first aid simulation. Depending on the particular first aid actions taken, and on the order in which they are taken, the patient may be helped and stabilized or further harmed. Simulations usually operate in cycles. Each cycle begins with a simulation in a given state. In this example, the simulation begins with the state of the victim just after an accident. Given that state, a variety of actions are possible (e.g., treat for shock, treat for bleeding). The student takes one of these actions and this puts the simulation in a new state. The simulation proceeds through repetition of this basic cycle.

The state of the simulation can be presented at various levels of detail. For example, the first aid victim could be represented simply by a few descriptive words on a display screen, indicating his or her vital signs. On the other hand, in a currently existing simulation of emergency cardio-pulmonary resuscitation techniques, the degree of "fidelity" to the real world is much higher, and the patient is represented by an actual mannequin.

A simulation can merely "stand in stead" of an actual object or system and faithfully mimic its change in state and response to student actions. More useful, however, is the simulation which interacts with the student, coaching him or her and providing feedback on the effectiveness or advisability of actions taken.

Simulations are good candidate instructional modes to select when they can help diminish the following:

- Reliance on expensive, scarce, or potentially hazardous actual equipment.
- Time required to gain relevant practice.
- Exposure to danger.

Simulation is an excellent way to prepare students for later actual equipment or problem-solving situations.

A special form of simulation is gaming. One has only to watch the appeal of computer-controlled video games to see the powerful effects such gaming strategies can have on student motivation. From an instructional design standpoint, gaming strategies can be simple or complicated, can involve static or dynamic (highly animated) graphics, or can be programmed for use by individual students or in a competitive team context. For example, for simple tasks in which students are required to learn lists of technical terms or steps in a maintenance procedure, gaming techniques--such as having students set and attempt to achieve learning time goals, where the computer keeps score and provides feedback--can increase student interest and learning in an otherwise boring and repetitive task. More complex gaming techniques can include the use of animated cartoon characters that probe or prompt learners on tutorial or drill-and-practice lessons.

The choice of gaming applications is best determined by a consideration of learning requirements and student characteristics. Gaming is appropriate for potentially boring, rote learning tasks or for complex and difficult procedural tasks that can benefit from the stimulation of student interest. Gaming may also be appropriate for students with motivational problems or who have had histories of academic failure. The ultimate decision to use gaming strategies rests on course objectives, student characteristics, the creativity and expertise of the CAI development staff, and the time available for CAI development. Some potentially good sources of additional information about gaming strategies can be found in the work of Dodge (1979, 1980) and Malone (1980).

5. Inquiry

The unique quality of inquiry CAI is in who defines the objectives of the instructional events the student or the course developer (from the Specialty Training Standards). In the case of inquiry, the student controls the interaction or dialogue; in tutorials, objectives have been defined by the author or developer (although the means for reaching the objectives may be as flexible as in intelligent CAI or as relatively inflexible as in very linear tutorial CAI). Inquiry allows the student to get to what it is he or she needs or wants to learn. Inquiry CAI, as opposed to information CAI, is an interactive instructional experience in which information, concepts, and/or rules may be supported with examples, and after which practice may be available at the user's (i.e., the learner's) discretion.

This particular form of CAI is especially appropriate to those who need refresher or brush-up training in very specific areas. Inquiry CAI is particularly "user friendly," often employing a series of menus from which to make information or instruction selections. In some cases, the user/learner may query the computer for specific information or instruction using the keyboard for English language input.

6. Intelligent CAI

As mentioned in the section on the tutorial, it is not easy to create courseware that emulates the one-on-one interaction of an instructional dialogue. Over the years, techniques have been developed that help approach this ideal. Taken collectively, these techniques are known as ICAI.

Specifically, it has been learned that in order to provide Socratic dialogues or meaningful coaching, three components of knowledge must be brought together and coordinated in the lesson. The first component that is required is subject-matter expertise. The computer itself must know how to solve the types of problems it is trying to teach, just as a human teacher would. Second, an accurate model of the student's current state of knowledge is required. What does the student know, what does the student not know, what misconceptions does the student have? Finally, using these first two components, the third is invoked: the rules of how to conduct an instructional experience (the means to master the instructional objective); included here is when to ask questions, when to tell or illustrate, when to review, etc.

ICAI is not yet a fully mature technology. The authors know of no ICAI courseware in routine instructional use. But its time has come, and the hardware and software exist to support some development. In many ways it serves to define what quality courseware should be, and its techniques can now be used in a limited manner in the design of more conventional tutorials.

In summary, several approaches to CAI are available. These applications are listed in Table II-2.

E. How Is CAI Developed?

1. The Problem

Although this is not an implementation manual, development issues are discussed briefly since they must be well understood in order to make an informed choice about whether or not to adopt CAI. Whether the plan is to develop courseware in-house, to have lessons developed by outside contractors, or to purchase/use existing courseware, it is important that the courseware development process be understood so that cost, development time, and staffing requirements can be realistically anticipated. If the development of courseware by contractors is being considered, then the requirements must be specified and

Table II-2

Summary of CAI Applications

Types of CAI Applications	Purpose/Application
Informational	To provide additional adjunct factual information during procedural learning or problem solving
Drill-and-Practice	To encourage transfer and generalization of concepts, skills and procedures learned or provide remediation through practice
Tutorial	To present instruction as a two-way interaction and encourage active responding during initial learning
Simulation	To provide practice of procedures or problem solving in life-like or job-like sequences or situations; can reduce reliance on expensive, scarce, or dangerous actual equipment. Gaming enhances learner motivation on repetitive, rote, or complex learning tasks
Inquiry	To allow learner-directed learning or review in specific areas
Intelligent CAI	To provide highly interactive, two-way dialogue that approximates human tutoring

provisions made to evaluate the product. Production cost will be better understood if the resources required for the different types of CAI are known. If in-house development of courseware is being considered, again there will be a need to specify requirements and be able to evaluate the resulting product. In addition, a CAI development staff with special skills to fill specific roles must be acquired, or else personnel must be trained for those staff positions.

Specific development roles and skills are in large part dependent on the approach and process used to design and develop courseware. Further in this subsection, a number of different CAI development approaches currently in use will be described. There are pros and cons with each approach, and the one chosen will depend on a number of factors, such as the following:

- Staffing resources - Is there an existing CAI development infrastructure, perhaps at the center-level or would this need to be developed?

- Development aids - Will CAI be developed using a development system that includes authoring tools, or will the work be done without those aids? (For a description of classes of design and development aids, see Section III.C.)

- CAI methods - How complex will the CAI be? Will very sophisticated simulations be developed or will less complex informational CAI be acceptable?

Whichever method is used to select a CAI design and development task, whichever approach may be adopted or adapted, the most important thing is that it should be controlled and systematic. If the project is systematic, more of a science than an art, then a necessary step has been taken to ensure timely development of sound CAI as cost efficiently as possible.

Assume a course has been through the ISD process and one or more instructional objectives are potential candidates for CAI treatment. After targeting an objective, the next step is deciding whether the use of CAI meets an instructional or organizational need. The objectives themselves will help determine the appropriate CAI method to use.

Having decided on a specific form of and role for CAI, its integrated use in the course will need to be considered. Will its adoption be disruptive to the course or course staff? How will revisions be made? Are revisions to the content expected to be frequent? H[illegible]taff be trained and transitioned into using CAI in the course? Will they [illegible]e benefits to or disruption of their traditional instructor roles? Let us assume that, after the resolution of these concerns and considerations, it is decided that CAI is going to be used in the course. Now, how can a form of instructional delivery be developed that takes advantage of some of the individualization and interactive characteristics not usually found in other instructional media?

2. CAI Design and Development Approaches

Over the past 15 years, several courseware design and development approaches have been used. While certain of these approaches have traditionally been identified with specific hardware systems, it is unfair to tie approaches to systems. Instructional design and engineering have and should increasingly become the driving force in the development of CAI regardless of the development hardware system. As stated earlier, there are pros and cons for each of the generic development approaches. It might be most helpful to consider these approaches first on their own merits and second, with a specific course, staff, fiscal, and time constraints in mind.

Four possible approaches are offered below.

Approach A: The Inspired Programmer-Author. This is the least systematic of all possible approaches to CAI development. It has been widely used with variable success. Typically, a subject-matter expert (SME) learns a programming or authoring language (see glossary or Section III.C) and proceeds to program lessons, typically "tutorials." Sometimes this approach is successful when:

- The author is enthusiastic and can get others to see the potential of the medium.
- The author intuitively understands the learning process and can organize the content and sequence the lesson to incorporate good instructional design.
- The author can organize the actual program such that it can be readily changed or updated by subsequent instructors or SMEs.

More often this approach has been notably unsuccessful because:

- The author considers the medium as a kind of automated programmed text, not taking advantage of its unique characteristics.
- The author develops the lesson to take advantage of the "flashier" characteristics of the medium (e.g., graphics or color) for their own sake, without considering the impact on student learning, and spends most of his or her time on this part of the development.
- The author does not carefully organize and document the lesson. As a consequence, when the lesson needs to be updated by another author, the task is impossible, and the original effort is lost.

Approach B: The Traditional Development Team. This approach also assumes that the developers will be using a programming or authoring language (see Section III.D). This approach most often uses a team:

- The instructional designer, who is responsible for managing the effort, sequencing the content, flow-charting the interactions, and providing the instructional strategies.

- The subject-matter expert, who is responsible for providing the lesson content for tutorials, the data base content for informational CAI, the practice items and context for drill-and-practice or, more representationally, for simulations. The SME is an integral part of the team but is more visible during the design and validation parts of the development effort.

- The programmer, who is responsible for coding and documenting lesson content and sequence as specified by the designer and SME.

- Other skills used in the team approach include graphics design, typing/data entry, technical editing. These skills are often incorporated in the roles of instructional designer, SME, and/or programmer and are more or less important in themselves depending on the size of the development effort; i.e., each role is individually important to a 300-hour CAI development project but may be subsumed under another role in a 2-hour CAI project.

This team approach is fairly standard among professional courseware developers. It takes advantage of the real expertise of each team member, not expecting those people to learn new skills (e.g., an instructional designer learning to be a proficient programmer). After working with the SME in developing a lesson script, the designer and programmer usually work up a flow chart for the lesson. This flow chart, plus the lesson script, are the documents used by the programmer to code the lesson. Although this approach helps ensure the quality of the courseware, it does require significant communications and resources commitment. This resource requirement has been the catalyst for the development of significant authoring aids that either minimize the need for a programmer by providing editors that help developers create text and graphics frames and the logic that strings those frames together or else minimize the need for the designer and programmer by providing these tools plus instructional strategy-specific design editors. This more complete tool has been implemented, at this time, very incompletely but holds promise for more efficient and effective courseware development in the future.

Approach C: The Computer-Supported Development Team. This approach assumes that editors are available that simplify text, graphic, and simple program logic specification and entry (without programming). This approach still requires the SME and the instructional designer. In addition, a programmer may be needed for the implementation of special routines or branching or probably complex or animated graphics. Developing a lesson outline, script, and flow chart is still necessary and should be completed before the lesson is developed on the computer.

A variation of this approach was developed and is currently being used for the first time in a very large CAI development effort by a major corporation whose computer-based education group was tasked with developing 800 hours of CAI in the area of aircraft maintenance. To systematically accomplish the huge development effort while maintaining quality control, this corporation designed a plan whereby SMEs were used as CAI authors. The difference between this approach and Approach A described earlier is that, in this case, the SMEs were briefly trained in specific, relevant instructional design issues and were given development guidelines and standards and style guidelines. They have the responsibility to check at specified intervals with the unit or team manager who is an instructional designer. The SME is also responsible for using the text and graphic development editor and the simulation development editor to enter and edit the on-line instruction, practice, testing, and simulations. Graphics artists are used for graphics design.

Approach D: The Computer-Guided Author. This is a new approach, requiring highly sophisticated development tools that help a design-naive SME make good decisions about the instructional design issues involved in the development of quality CAI. These tools are just now becoming available and are relatively expensive (see Section III.C.4). More and more flexible development aids of this sort will become available because they will allow the time- and resource-efficient development of quality CAI. Some preparation for the design editor-human developer interaction is still required, but the computer-based editors themselves will be able to provide some qualitative information to the author and prompt the developer with course information necessary to create instructional sequences.

F. How Can CAI Meet Organizational and Instructional Needs?[1]

The Air Force provides the following instruction in the technical training context:

1. Primary or mainline training, which is the course content itself.

2. Remediation that provides alternate instruction in unmastered course objectives.

3. Enrichment and course elaboration to take individuals beyond minimum co ..e instruction.

4. Refresher or brush-up instruction to previously trained individuals.

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[1]Information for this section is based heavily on information provided by the Air Training Command.

5. Course prerequisite or fundamentals to bring entering behaviors up to par.

6. Basic and study skills development.

The Air Training Command has an annual matriculation of over 270,000 trainees in over 2,800 courses. Of the seven major mission tasks for which ATC is responsible (information presentation, demonstration, drill-and-practice, evaluation, feedback, remediation, and data collection), six are directly instructional while the seventh is an instructional management task. This mission is currently experiencing a severe strain: More and more is being demanded of instructors and instructional resources, while the trained instructor staff continues to decline. The Air Force is experiencing a pressing need to train more first-term airmen while at the same time suffering retention problems with longer-term personnel who can act as experienced instructor staff.

In addition to the pressing resource problem is the need to provide technical training on increasingly complex equipment and with increasingly complex processes. With the decrease in resources and the increase in demand for more and more complex training, ATC is looking for means to provide more instruction while maintaining quality control.

The use of CAI holds the promise of providing a tool to help bridge the discrepancy between supply and demand. Specifically, CAI can provide direct or adjunct support for meeting the first six previously mentioned major ATC mission tasks.

As noted in the subsection entitled "What are the limitations of CAI?" and in the subsection following this entitled "What are the organizational impacts of adopting CAI?" CAI cannot meet all of ATC's instructional requirements; and the impact of implementing the technology takes careful planning, accommodation, and investment.

G. What Are the Organizational Impacts of Adopting CAI?

There are two broad areas in which CAI development and implementation will impact and change most organizations:

- Resource Requirements
- Organizational Infrastructure/Technology Adoption

Each will be described separately; however, there is at least one umbrella management issue for both areas: the requirement for careful short- and long-range planning for project development, implementation, and ongoing support. Specific, detailed descriptions of requirements will be covered in Section III.

1. Resources

The major resources categories include hardware, software, courseware, physical and human factors, and personnel. Some of the institutional impact concerns in each category are described briefly below.

a. Hardware. The management of an organization implementing CAI will find it essential to perform a survey or needs assessment to determine hardware requirements even if only a small need is anticipated. How much hardware is needed, for the short term and for the long term? What type of equipment will be required, from stand-alone microcomputers, to clusters, to a large networked timesharing computer with terminals? What functions will the system be required to perform?

A small sampling of plausible tradeoff scenarios that will result in differing hardware decision outcomes follows:

- Will there be one course of 15 students of whom only a few will use CAI for basic skills upgrading, or must there be enough hardware to support several courses with a large number of students who will use CAI for much of their normal curriculum?

- Should equipment be leased because the need is limited or of short duration, or should the hardware be purchased because the need is substantial and is expected to be ongoing?

- Does CAI software exist that can be used on the existing hardware—and at what cost to the other functions the current system must perform? (The issue of using a currently functioning noninstructional computer to perform the instructional function as well is extremely complex and will not be treated in depth in this handbook.)

- Will the hardware be required to support functions such as animation, color, etc., or will simple black-and-white displays that support line-drawing-type graphics be adequate, or are graphics required at all?

- Should the hardware be available in several locations at the training center so access to terminals is convenient and logistically appropriate for all users (instructors and students alike), or is the training center compact, with a potential computer-based instructional center easily accessible to courses and personnel that require it?

b. Software. Software decisions will also be based on the results of a survey/needs assessment. Software is an essential part of the computer-based resource requirement. Software provides instructions to the hardware and can roughly be categorized into the following: the **operating system** that gives instructions to the hardware, allowing computer programs and equipment (including computer languages) to function; **computer languages** that allow a programmer to address the computer efficiently; and **application programs** written in computer languages that perform or allow specific functions and human-machine interactions.

For example, assume work is being done with one of the popular microcomputers. That micro might have an operating system that allows the computer to receive input from an attached computer keyboard and give output through a TV screen. Compatible with any particular operating system and specific micro are several computer languages, such as BASIC and PASCAL, with which application programs are written. One such program is VisiCalc, a financial spreadsheet program.

There is a kind of program termed **instructional software**. Instructional software helps instructional designers/authors create material to be delivered on the computer. Instructional material delivered on a computer, is termed **courseware**. Just as VisiCalc (the tool) should be distinguished from a given, specific financial spreadsheet (the product), the distinction between instructional software and courseware should be clearly understood.

c. Courseware. As stated previously, courseware is the generic term for all types of CAI materials. (The Navy uses the term lessonware instead of courseware.) Courseware is a resource that can be acquired in already developed programs. However, in most cases, it is developed by the potential user. In the future, there will be libraries of courseware just as there are libraries for paper-based materials, but for the present, it will be important to plan either for the in-house design and development of courses involving some very specialized personnel skills or else for contracting with an outside developer for the materials (see Section V.A).

Once the materials have been developed and validated and are being implemented, resource personnel for courseware revision and maintenance will need to be considered. This process should be planned for at the beginning of a project. For example, if the materials are anticipated to need frequent revision, the initial development of the materials could be accomplished in such a way (e.g., through modularization) as to facilitate the revision process. Recurrent need for courseware updating and revision will be an important input to the decision regarding in-house or outside development. It will also be a consideration in the decision as to how the courseware is produced (i.e., via programming or through authoring editors).

d. Physical and Human Factors. The use of CAI requires special thought and consideration for its housing and the housing of the necessary development and support personnel. The hardware, associated documents (e.g., workbooks), and furniture (e.g., carrels, tables, chairs) all need to be financed and procured and will require space. Some computers may require special electrical hook-ups and air conditioning. Changes to classroom facilities also have to be assessed (e.g., room size, carrel layout, instructor station), as well as a variety of human factors issues in classroom design (e.g., lighting, air quality, room color, other comfort factors). All of these considerations have to be taken into account to some degree when planning for the development and implementation of a CAI project.

e. Personnel. People issues need to be considered: numbers, needed skills, roles, and training. Consider this representative list of roles generally required in CAI development and implementation of any magnitude:

1. Managers. These personnel are in charge of developing the course training standards (including media selection decisions); keeping development on target, both in terms of development schedules and quality control; overseeing the CAI center if there is a center; and managing both courseware and hardware maintenance. Cost control and fiscal management are also the manager's responsibility.

2. Developers. Instructional designers, subject-matter experts, programmers, and graphics artists are needed. Personnel with these skills create and maintain the courseware.

3. Advocate/Promoter. If you plan to have a viable CAI center, research has shown that it is very important to have one or more people promoting project visibility within your organization, top to bottom. Even within a small project (i.e., with a single course), it is important to have a person responsible for "consciousness" of the potentials of the medium as new personnel rotate in and out of the course.

2. Infrastructure--Adapting for Change

What organizational infrastructure does CAI require if it is to be an effective, efficient, and accepted component of a specific training program? There are at least two requirements:

- Facilities

- Communication among personnel affected

Section II.G, regarding the institutional impacts of adopting CAI, mentioned the range of possible hardware configurations and the ways in which training requirements affect hardware selection. Whatever decisions are made regarding hardware, it is absolutely essential that the users of the equipment have adequate access. In a comparative analysis of numerous successful and unsuccessful CAI projects (Avner, 1977), access to terminals was cited as one of the major indicators of success. In assigning space in a facility for CAI, consider the following question: "Am I maximizing access to the terminals?"

To illustrate this point, consider two options: (either might be the preferable one in a specific situation). Option 1 is to centralize access and put all terminals in a big center, and Option 2 is to decentralize terminals or microcomputers in course classrooms or offices. If many of the courses will be 100 percent CAI, or if many of them will use CAI as "homework" outside of class, a centralized configuration of terminals might be preferable. But if a course incorporates some CAI but is not totally CAI-based, a long trip down to the CAI center might dissuade course supervisors from a continued commitment to CAI because of the logistics of arranging for the transportation of individual students to a central CAI facility.

The centralized approach is attractive in several ways. Maintenance and management by an infrastructure of CAI staff members of courseware and hardware can be more easily accomplished if the equipment and staff are in a single location. But this centralized approach also has two potential drawbacks. These potential drawbacks should be considered when planning facilities in conjunction with potential use of CAI in a particular course. A recent study of the factors critical to the success or failure of self-paced instruction in the Air Force (McCombs, Back, & West, 1984) indicated that both the literature and case studies have shown that **courses which are 100 percent self-paced have seldom been successful.** Self-pacing only that portion of a course which lends itself to the self-paced format (and similarly utilizing group-pacing and all other instructional approaches where they appear well suited) yields superior results. With this in mind, very few courses should be 100 percent self-paced or 100 percent CAI, and this suggests only infrequent justification for a centralized room of student terminals. It also suggests the need for very flexible scheduling.

The second potential drawback is that CAI is a fairly new medium for many instructors, developers, and students. It stresses individualization and interactivity. In many ways it goes against the grain of established, instructor-centered training practices. Given that a good case is built for this new medium for a training facility, an additional need is to plan for overcoming a natural resistance to CAI in particular and to change in general. Locating all terminals or microcomputers in one large center may minimize the effective visibility of the innovation. Maximizing the visibility can be attained by installing terminals or micros throughout the facility. Gradual introduction of CAI to staff and students could be accomplished by using it for simple functions like completion of homework.

The second "infrastructure" is people. Unless a network of commitment to CAI is fostered, the successful adoption of CAI will be in jeopardy, and may even be actively sabotaged. The late President Lyndon B. Johnson once remarked, "If they're not in on the takeoff, they won't be in on the landing." Designers, supervisors, instructors, students, and evaluation teams must be involved as the project takes off. No instructional approach will work if these groups of individuals are not committed to a common objective. The establishment of an infrastructure to support communication among these personnel, in the final analysis, is the most important challenge in successfully launching a CAI project.

Just as it is important that the various role players have access to each other from the beginning, it is important that each role player has convenient access to the CAI medium. If it is difficult for instructors to get on-line, then it is harder to win their commitment to CAI. Work toward fostering a sense of "ownership" among the personnel. If the course ISD personnel do not have meaningful, job-related access to the new CAI system, they will be discouraged from becoming involved. It may be very helpful to acquire some technical assistance formally through consultants within or outside DoD when considering specific personnel infrastructure options. Informal contact with others within ATC who have faced a similar situation may result in help from their "lessons learned." Some of this assistance/referral information has been supplied in Sections I and V of the handbook.

The CAI medium itself may be the best ally in setting up communication among role players. For the smallest applications, networking may not be needed. But for larger applications, networking of hardware may be a catalyst for communication. This may be limited to a kind of "mailbox" feature whereby notes between users can be "sent" and received on the terminal. This may be extended to elaborate integrated design, development, delivery, and evaluation systems, of which computer-managed instruction may be considered a prototype.

In sum, adoption of CAI requires providing easy access to terminals and building a people infrastructure. Computer networking provides a means to meet each of these requirements.

H. Will CAI Be Cost Effective?

This section is provided to identify relevant issues and to summarize current research on the cost effectiveness of CAI, since costs are a basic issue in the consideration of system change.

Cost-effectiveness R&D relates the costs of instruction to quantifiable measures of the effectiveness of graduates as the result of the training received. According to Orlansky and String (1979), there are two ways of evaluating the cost effectiveness of alternative military training systems. When comparing two systems of the same cost, the system that provides greater effectiveness would be, of course, preferable. When comparing two systems of the same level of effectiveness, the system that costs less would also be preferable. All military studies of CAI have used the latter approach.

In order to assess the effectiveness of CAI, perform the following analyses:

1. Identify the costs of traditional instruction

2. Identify separately the costs associated with the development, implementation, and operationalization of CAI instruction

3. Measure the effectiveness of trainees in the field who are graduates of each mode of instruction

4. Identify the costs of repairing any deficiencies associated with the current training methods

5. Compare the two systems to determine if the investment in CAI is warranted.

In general, there are few baseline data available on the performance effectiveness of Air Force technical training graduates with which to contrast CAI-trained people; therefore, there is no body of literature that can be used as reference when estimating probable cost effectiveness. As an alternative to performance measures, most studies rely on training objectives with which to compare effectiveness, by posing the question: Will CAI improve the performance of students as measured by test scores, time to completion, and amount of material covered? There are many problems associated with this alternative. Orlansky and String (1979) listed the following:

> Student achievement in school as shown by test results may serve as a proxy (or predictor) of future field performance, and hence, training effectiveness. However, correlations between performance at school and on the job have not been established for any method of instruction, and the use of results collected only at schools cannot be taken to be conclusive.
>
> Such data (supervisor ratings) are subjective in nature and may be influenced by factors not related to training, e.g., relevance of the training course to the actual job, nature of the work environment, personality, and so on.
>
> The effectiveness of computer-based instruction for teaching a particular course should be compared to that of conventional instruction by measuring how well graduates taught either way perform the same tasks in the field.
>
> To the extent that student time is relevant to the analysis of cost effectiveness, it is a measure of the cost and not of the effectiveness of training.

Research studies on the cost effectiveness of CAI have been inconclusive. While most studies have indicated that CAI results in significant time savings when compared to conventional instruction (Jamison, Suppes, & Wells, 1974; Kulik, Kulik, & Cohen, 1980; Sprecher & Chambers, 1980), others report that CAI saves little time beyond that saved by manual individualized instruction (Orlansky & String, 1979). Studies conducted to estimate the training effectiveness of CAI are rare. Most cost studies have been conducted independent of effectiveness (Shavelson & Winkler, 1982). Braby et al., (1975) have developed, "A Technique for Choosing Cost-Effective Instructional Delivery Systems," which includes CAI.

Section III of this handbook provides some guidelines for estimating the costs of procuring and maintaining CAI system components. CAI systems range from very small and simple to very large and complex. In order to estimate the costs of implementing and maintaining a CAI system, the design characteristics must first be selected based on training needs. Sections III and IV provide assistance in the selection of specific features and configurations of CAI that might fit some specific requirements.

Cost estimates are extremely variable. Orlansky and String (1979) suggested that the most meaningful relationship for comparing CBI with other methods is the cost per student hour. Hickey (1975) estimated the cost of CAI lesson preparation to range from 40 to 200 hours of instructor preparation time per hour of presented lesson, at an average cost of $1,000/hour of lesson presented. If the preparation cost was amortized over 4 years, estimating 200 students per year, it would be approximately $1.25/terminal hour. Given these estimates, it would appear that CAI is efficient only in courses with high student flow. While accurate in 1975, Hickey's estimates do not reflect current costs for CAI preparation.

Shavelson and Winkler (1982) reported that estimates of the cost of developing an hour of courseware vary between $300 and $3,000 and that the cost of CAI delivery varies between $0.40 and $28.50 per student hour. They attributed some of these cost differences to assumptions made about system components, rate of use, and life span of hardware and software. They predict that advances in courseware development software, such as authoring and design systems (see Section III.C), will have a major impact on courseware development costs from now on. Additional variables they identified as influencing costs include student characteristics, quality of courseware, and type of instruction (drill-and-practice, tutorial, simulation, etc.). Further, they cautioned that most studies focus on hardware costs, and Levin and Woo (1980), reported in their cost analysis of a time-sharing system that computer equipment represented only about 28 percent of the total annualized costs, so that even if equipment costs declined by one-third, total costs would be decreased by less than 10 percent. Shavelson and Winkler also cautioned that shifting instruction from a labor-intensive (teachers) to a capital-intensive (equipment) effort may be an illusion in that rather than reducing personnel, the introduction of CAI may simply affect the skill mix of instructional personnel and related staff. It should be noted that the data in the Shavelson and Winkler paper, as well as most other published papers, were derived from public educational and not military training systems. The impact of this fact on interpreting the data for military training systems is probably substantial.

Most decisions to implement CAI, therefore, are based on the consideration of benefits rather than on cost effectiveness. Numerous studies have indicated that CAI raises student achievement, reduces training time, and engenders positive attitudes toward the computer. As with any form of instruction, the quality of the courseware, the nature of the instructional goals, and the type of CAI used are all important variables. Quality of materials is particularly important in this medium. Most researchers agree that since methodologically adequate cost effectiveness studies of alternative mixes of instructors and computer delivery mixes are not generally available, the decision to adopt CAI should center on individualized goals and requirements, and anticipated benefits of CAI.

For the training organization, the impact of these cost benefits can be thought of as being either internal or external to the organization. An external cost benefit might be either the reduction of training time or the reduction of student attrition. These benefits are external to the organization because they impact cost centers other than the training organization. An external cost center that would be affected by reduced training time or student attrition would be the personnel system.

Internal cost benefits are associated with the training organization's cost of providing training. Maximizing the productivity of instructor personnel, reduction of support staff, and increased utilization of facilities are all examples of benefits which are internal to the training organization. Effectiveness in achieving such benefits will vary from one instructional approach to another. Likewise, the cost will also vary. When the adoption of CAI is being considered, a great deal of thought must be given as to how CAI will assist the organization in more efficiently achieving its training mission.

It is stated in the handbook several times that a benefit of CAI is the provision of individualized instruction. Other instructional approaches can also provide individualized instruction. Instructor tutoring of individual students is one example. Another example is programmed text instruction. Before any of these approaches can be evaluated for cost effectiveness, there will have to be an assessment as to what benefit will accrue to the organization by having individualized instruction.

If it can be determined that individualized instruction will reduce student attrition, then this will have a direct cost benefit to the organization. Now the question to ask is how to achieve individualized instruction. One way would be to provide more individual instructor tutoring. This may be impossible without significantly increasing instructor staff--a negative cost consequence. This might leave programmed instruction and CAI to consider. Programmed texts are limited in their capacity to accommodate individual student abilities; i.e., they are nonadaptive. If the student population is generally bright and of the same ability level (i.e., advanced students), then this limitation of programmed text might not be important. On the other hand, if your student population is highly variable in ability, then the adaptiveness of CAI would seem appropriate. However, as has also been mentioned, the development of good, adaptive instruction for CAI requires personnel with special skills. The availability of such personnel might be limited. The cost of acquiring such personnel now has to be evaluated against the cost of acquiring additional instructors to provide individualized tutoring. In both cases, the negative cost factors associated with each alternative have to be compared with their respective cost benefits--in this case, the reduction of student attrition.

In considering potential benefits of CAI, an additional factor to examine is the cost implications of having the technology in place with which to develop communication capabilities and the administrative and management functions typical of CMI in the future.

Anyone attempting to approach the adoption decision based on cost considerations should recall that many of the costs associated with the implementation of a new system are those that would apply equally to an upgrading of the present delivery system. Do the data show what the present system costs? What are its deficiencies, and what would it cost to make the changes necessary to reach the present training goals?

This discussion of cost implications can be summarized by the following algorithm:

1. Are there objective measures of effectiveness (i.e., job performance)?

2. Can training outcomes be correlated with measures of effectiveness?

If either 1 or 2 can be answered affirmatively, then,

3. Compare instructional approaches based on their impact on effectiveness relative to costs.

If neither 1 nor 2 is possible,

4. Assess cost benefits for the organization.

5. Assess cost requirements for alternative instructional approaches.

6. Compare the benefits against the additional cost requirements of each alternative approach.

There is no clear guarantee that CAI will provide substantial cost savings associated with instruction. There are indications that there is a number of potential cost benefits, depending on the requirements, the system chosen, how well it is implemented, and how well the system and the needs are matched.

When a cost analysis is performed to determine whether CAI is viable for a specific training application, the benefits to be expected must be carefully described--benefits both to the training organization and to the organizations to which a training service will be provided. It is only after the desired benefits have been determined, and how to measure whether those benefits have been achieved, that the concept of effectiveness can be addressed. Effectiveness is a measure of the degree to which a benefit has been achieved. A benefit can be described in terms of either performance or cost. Alternative options are then compared on the basis of their ability to positively affect either the performance of the product or the efficiency of the process.

III. CRITICAL FACTORS FOR ADOPTING CAI

A. Use of This Section

This section is intended to identify specific hardware, software, and courseware factors, issues, and considerations in the CAI selection and adoption process. Information concerning hardware systems, hardware components, CAI development software alternatives, and issues concerning courseware are provided in a modular data format. Embedded within the subsections are advantages, disadvantages, and tradeoffs for different alternatives, as well as practical suggestions for planning and procurement.

While this section treats critical CAI system issues, there are other critical aspects that the user will need to explore in the training environment. There are instructional and institutional factors, issues, and considerations which must be addressed through a thorough front-end analysis of a course or courses under consideration.

This section is intended to be used both as a reference tool during the decision-aiding process (Section IV) and as a general library tool for obtaining an overview of available CAI options. The use of visual mnemonics for many of the data points provides a ready reference to the requirements associated with each hardware, software, and courseware component. The visuals are intended to provide users with readily visible summarized information relative to other alternatives of the same issue (e.g., central, modular, or stand-alone computer system configurations). Comparisons of the data points in each are made relative to the other alternatives.

To aid in comparing the visuals for all alternatives within a hardware, software, or courseware category, they are grouped and listed below.

B. CAI Computer Hardware

Central Computer Configuration
Modular Computer Configuration
Stand-Alone Computer Configuration

C. CAI Software Support

1. Higher Order Languages
2. Authoring Languages
3. Authoring Systems
4. Design Systems

D. Courseware

1. Informational CAI
2. Drill-and-Practice
3. Tutorial CAI
4. Simulation
5. Inquiry
6. Intelligent CAI

Whenever possible, comparative information for several component alternatives has been placed on the same page.

Specific cost data have been included, especially in the hardware section. The prices and price ranges are likely to change rapidly, but are accurate as of the first quarter of 1983. Large purchase price breaks are, naturally, not reflected.

B. CAI Computer Hardware

1. Central Computer Configuration

Section Technical Vocabulary[2]

processing	"dumb" terminal
time-shared (sharing)	microprocessor
mainframe	multiplexer
minicomputer	downtime

In this type of configuration, as shown in Figure III-1, all CAI capabilities are accessed from a central computer facility containing all of the processing and memory storage capacity of the system. All CAI terminals are connected to the central computer and share the use of this computer and the CAI programs stored within it. Because of the allocation of processing time, through a special program in the computer, centralized computer systems are often referred to as time-shared systems. The computer in a centralized system tends to be either a mainframe computer or a minicomputer (see 4.1.1 and 4.1.2 in this section), but can also be one of the newer, powerful microprocessor-based mainframes (see 4.1.3). The CAI terminals in a centralized system are often referred to as "dumb" terminals because they have no capacity to process information without being connected to the central computer. The full-capability PLATO system is an example of a large, centralized CAI development and delivery system that is hosted on a mainframe computer. Such a system can be purchased or development and delivery services can be leased through national networks. The TICCIT (Time-Shared, Interactive, Computer-Controlled, Information Television) system is an example of a minicomputer-based, centralized CAI system. By way of contrast, a PLATO system can time-share up to about 1,000 terminals; a single TICCIT system can time-share up to 128 terminals in close physical proximity.

Advantages

The major advantage of a centralized system configuration is that a powerful computer with a large memory capacity can be shared by many users. In a centralized system, a single copy of a program can be shared by all users. If the centralized CAI system collects student data, then these data are usually available immediately to instructors or training managers monitoring the system. Archiving functions and the overall management of software-based instructional materials (i.e., courseware) are simplified with a single location for processing. A centralized system can also provide a means of easy communication between

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2See Glossary, Section V.B.

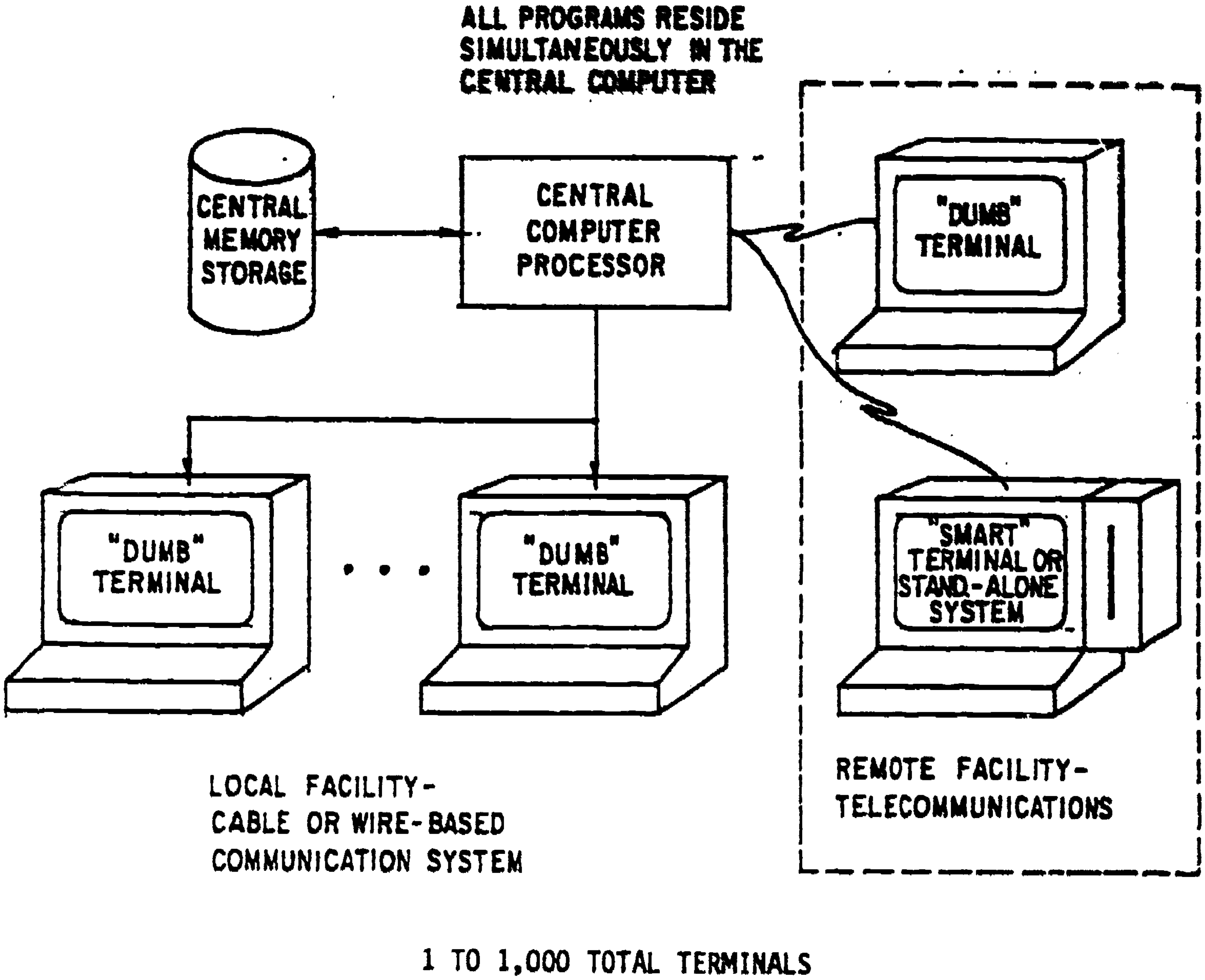


Figure III.1. Central time-shared CAI system configuration users through a message or "mailbox" feature. Because centralized configurations have been available for the longest time of any configuration, extensive support features, services, and experiences are available to users.

Disadvantages

The major disadvantage of a centralized system is its lack of local control. All users of the system are totally dependent on the operations of the central computer facility. If the central computer system becomes inoperable, then all CAI will stop. Generally speaking, programs that exist on the central computer are designed to be useful to the maximum number of users. The complexity of processing activities in a central computer system is high because many different programs can potentially be run simultaneously. The number of users on a central system affects the responsiveness (called response latency) of the system to a single user. The provision of specialized programs for local use may be limited, especially if the number of specialized programs becomes large enough to require sizeable increases in memory storage (see 4.2).

1.1. Cost Requirements. There are three ways in which to acquire this type of CAI capability: purchase a computer system for CAI use solely, lease CAI capability from a network, or adapt an existing computer capability currently used for non-CAI tasks such as data processing. Because the third option is so variable, it will be excluded from discussion. With a central computer configuration, the cost is weighted toward communications, especially for leasing services, and toward communications plus purchase price if a centralized system is being procured. Communications are important cost factors especially if terminals are physically remote from the central facility, because of the recurring cost of dedicated telephone lines. These costs can be quite high, depending on location and on multiplexing capabilities. When centralized systems are purchased, operational and maintenance costs are generally high because of the need to ensure that downtime of the computer is minimized.

1.2. Staffing Requirements. A purchased centralized CAI system configuration usually requires a substantial administrative and system programming staff to coordinate user needs and to provide maintenance of system programs.

A leased/licensed centralized configuration usually requires some administrative coordination but generally does not require maintenance or system programmers.

Both purchased and leased/licensed systems will require courseware development staff members if CAI is developed in-house. The exact staff descriptions depend on software tools available (see Section III.C).

1.3. Facility Requirements. A purchased centralized CAI system configuration is used when it is logistically feasible for a fairly large number of users to share a common set of hardware, software, and courseware resources. As a consequence, a centralized system typically requires a central computer facility for the central processor and its related memory storage equipment. Depending on the type of computer processor (see Section III.B.4), this central facility can require special environmental supports such as air conditioning and increased power capacity. A centralized system is particularly vulnerable to power outages because if the central computer goes down, all CAI ceases. For this reason, the facility for a central system typically has a redundant emergency power system. With a centralized system, as the system grows, the special facilities also have to increase. Such facility expansion can be costly. Lack of sufficient space to grow can limit the increased use of a centralized system.

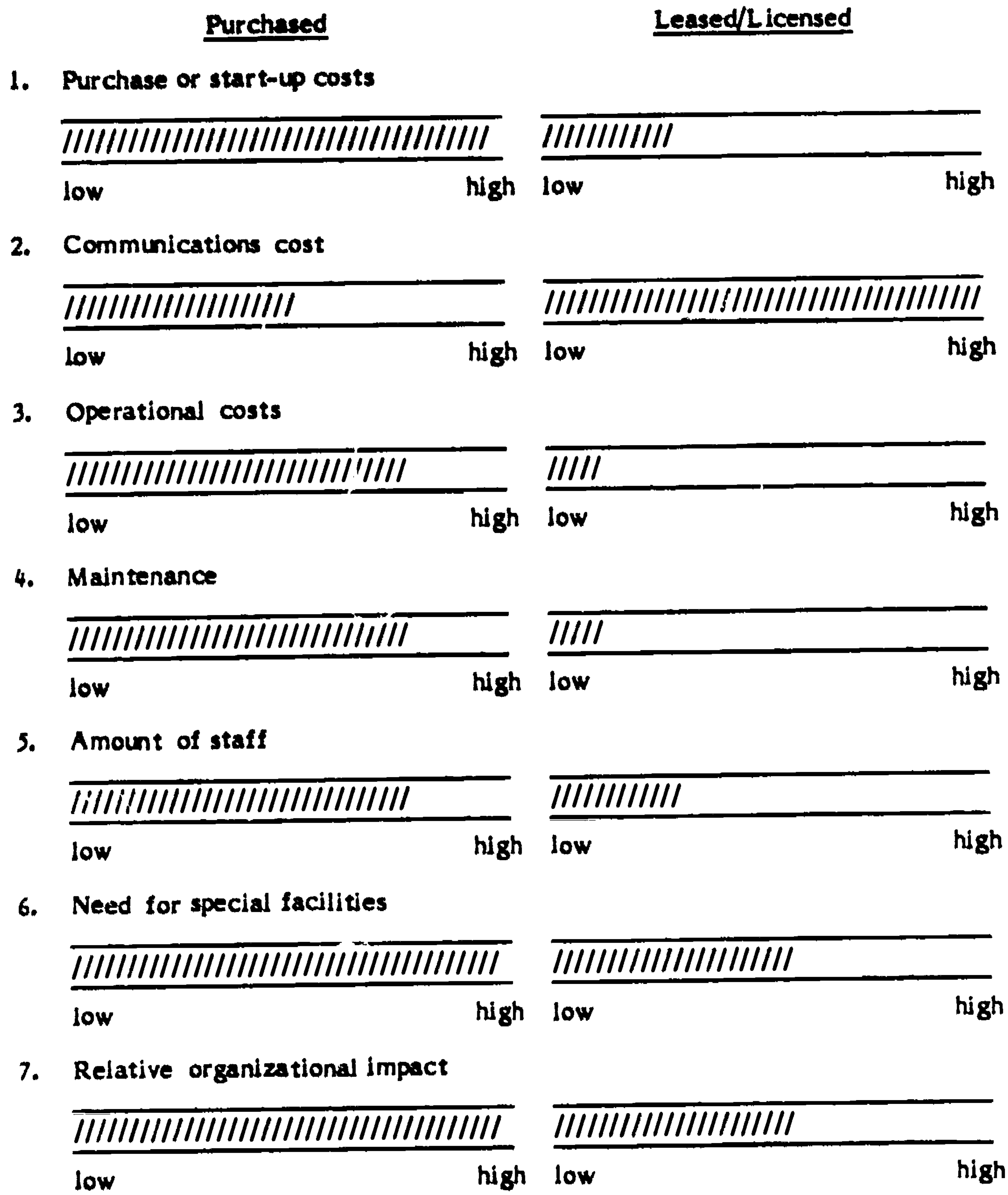
A leased networked, centralized configuration, such as PLATO, requires telecommunication and normal office or classroom-style facilities. Lighting and adequate electrical outlets are the only special facility requirements.

1.4. Organizational Requirements. In a centralized CAI system, changes made to software or courseware can potentially affect all users of the system. Organizationally, a centralized system requires a strong configuration management capability to ensure that all software and courseware changes are properly justified, documented, and authorized before being made. It is imperative that one local user cannot make changes which inadvertently cause problems for other users of the system. The ability to accommodate the special needs of local users requires that the design of the system configuration be carefully considered during the adoption and planning period for a CAI system.

1.5. Procurement. Because in a centralized system the hardware and software resources are shared by all users, care has to be taken prior to procurement to ensure that the needs of all potential users are carefully assessed. Adaptation of a centralized system to local user requirements after the initial system procurement can be very costly, if not impossible. Also, because a centralized system is usually justified on the basis of a large number of users, the initially procured hardware should generally meet the expected maximum capacity of the total system. This particularly impacts the facility requirements. This means that for a centralized system, the procurement process should take into account a large initial capital investment. For commercially available central CAI systems, the leasing of access time rather than outright purchase should also be considered.

B. CAI Computer Hardware

1. Central Computer Configuration[a]



[a]As in all subsequent figures, the requirements shown above are relative to all other alternatives for this heading.

B. CAI Computer Hardware

2. Modular Computer System Configuration

Section Technical Vocabulary[3]

processor(s)	main memory
central processor	disk drive
"dumb" terminal	operating system
file management capability	upward compatible
byte	downtime
megabyte	configuration control/management
multitasking (computer) operating system	downloaded

A modular computer system configuration is illustrated in Figure III-2. In this context, the term modular refers to the capability of a single processor type (e.g., a microcomputer) to be configured either as a stand-alone computer or a central computer. A modular computer system configuration is one in which there is a central processor to which several "dumb" terminals are connected under a multitasking, multiuser operating system and additionally, to which also are connected several independent computer processors. The independent processors can be configured either as stand-alone devices or as time-shared systems controlling their own set of dumb terminals. An important guideline to remember is that at all levels of the modular computer system configuration, the same computer processor should be used; however, at each level the type and quantity of memory storage will vary. If the same processor is not used at each level within the modular system configuration, then care should be taken to ensure that all processors used are software compatible (i.e., the same program will run on all processors without having to be modified).

As an example, in Figure III-2, the processor used as a central controlling and file management capability might have 1 million bytes (1 megabyte) of main memory and 40 megabytes of hard disk memory storage. This central processor would also have an operating system that would allow several terminals or independent processors to time-share its stored programs and files. The independent processors that connect to the central processor would typically have less main memory (e.g., 256 kilobytes) and a smaller amount of disk storage (e.g., 5 megabytes). The independent processors are capable of running CAI courseware without being connected to the central processor. However, periodically the independent processors would interact with the central processor for the purpose of exchanging information or to retrieve new CAI courseware. Each independent

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[3]See Glossary, Section V.B.

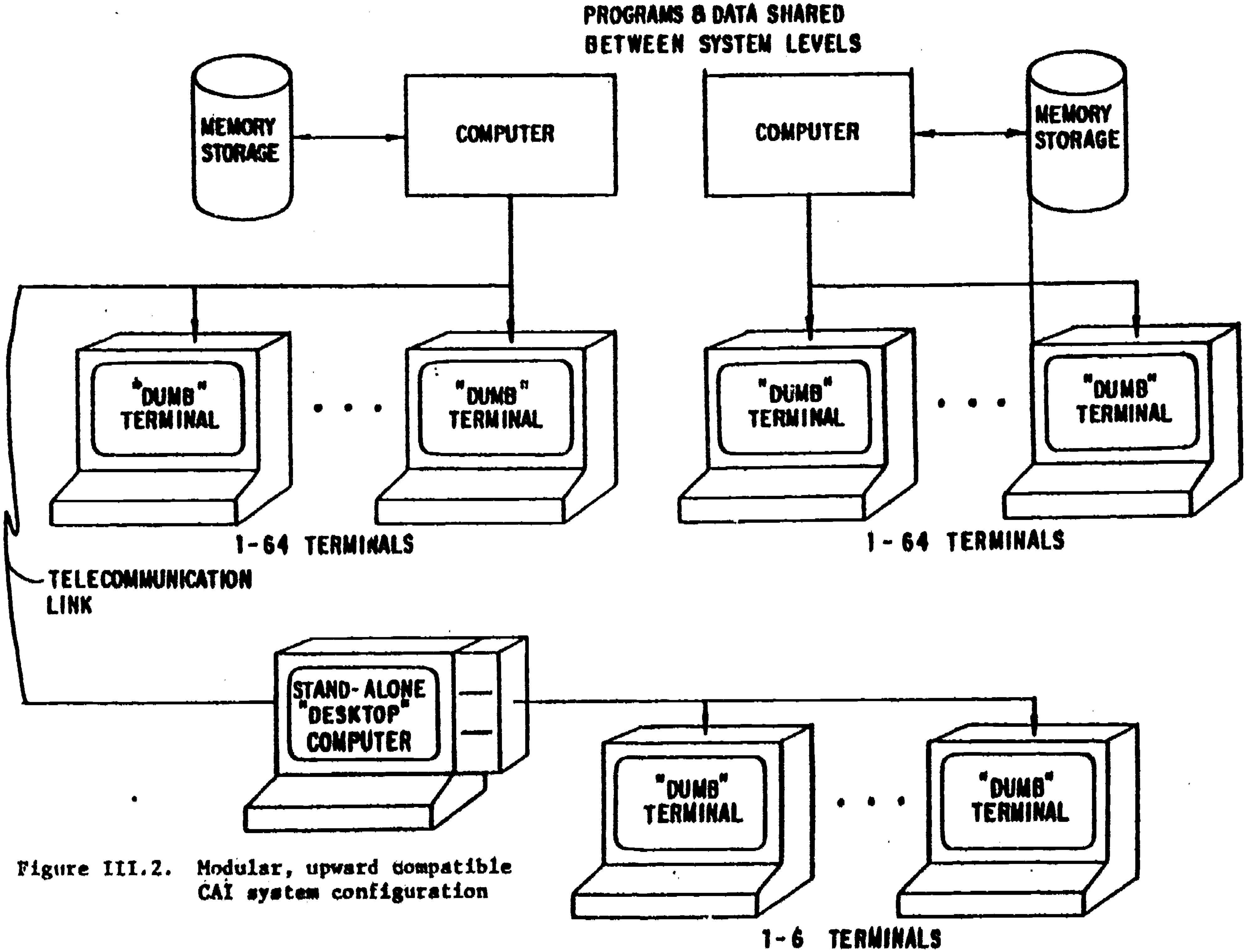


Figure III.2. Modular, upward compatible CAI system configuration processor can function as a single-user capability and could also drive a limited number of dumb terminals (i.e., 2 to 8).

An example of a commercially available, modular type system is the WICAT Computer-Based Instructional System. In the WICAT system, there are two processor levels. The first is a System 200 which serves as a central processor and the second is the System 160 which serves as an independent, desk-top computer. Both the System 200 and System 160 are based on the same microcomputer processor.

Advantages

The major advantage of a modularly configured CAI system comes from its flexibility. In a properly designed modular system, the CAI software is upward compatible, making it possible to adopt CAI on a limited basis using "desk-top" versions of the system's computer. As need and/or interest increases, the system can be expanded to include a central processor that will permit several users or groups of users to share a common set of courseware, and it can also provide for central data collection. Because of the upward compatibility of the courseware material developed on or running on the independent processors, this courseware can later be uploaded to the larger central computer. This type of flexibility permits an evolutionary type of growth in CAI application.

Another advantage of the modular system is that the downtime of one processor in the system does not affect other users on different processors. Also, response latency is not degraded as in a centralized CPU.

Disadvantages

A disadvantage of a modular-type system is that the redundancy of computing power between a central processor and several independent processors can be more costly than a comparable centrally configured system. However, the lower maintenance costs of a modular system could easily offset a higher equipment cost. If analysis shows that the initial CAI application can support a large number of students in a single geographic location, then the user should carefully weigh the costs of a central system versus a fully modular system supporting the same number of students.

Configuration control can be a problem with a modular-type system. Users of an independent processor could download a lesson from the central unit and then make modifications to it. After a period of time, standardized materials could become dramatically changed and be quite different among the independent nodes within the system. Another consideration associated with configuration control in a modular system is that associated with courseware development. If courseware development occurs on a central unit in the modular system, care has to be taken to ensure that the developed program is "sized" correctly so as to be able to be downloaded to a smaller delivery unit within the system.

2.1. Cost Requirements. The major cost factor in the modular system is associated with the redundancy of processing capacity. Independent processors should be used when recurring communication costs from scattered and remote users to a central system will be excessive or when special processing applications, such as simulation programs, place a heavy burden on the processing capacity of the central unit.

A modular system can allow the separation of development costs from delivery costs. A more powerful version of the basic computer can be used as a central development system while smaller, less sophisticated, and more numerous versions of the basic computer can be used for delivery. If a modular system has specialized CAI software, the purchase or licensing costs for that software needs to be carefully assessed. A separate software license for each processor in the system may be required.

Maintenance costs for a modular system are generally less than for a central, mainframe system.

2.2. Staffing Requirements. Typically, a modular system will require less staffing than will a large central CAI system. The hardware is usually less complex than for the large central system and thus requires a smaller maintenance staff. In a modular system where there is a central "development" site networked to several independent delivery sites, the development site will require a formal staff of system and application programmers (the latter would be replaced by instructional developers using an authoring language or authoring system). Administrative staff is project dependent, with variables including the size of the project, whether or not development is centralized, etc.

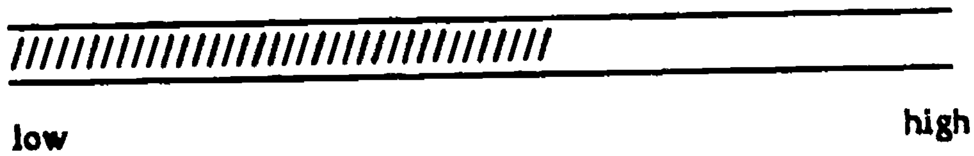
2.3. Facility Requirements. The hardware of modular-type systems involves either minicomputers or microcomputers. As a consequence, there is normally no need for special facilities to house the system hardware beyond what is generally required for security, comfort, and accessibility.

2.4. Organizational Requirements. With a modular-type system there are two organizational options. The first option is to separate development functions from delivery functions. With this option, an organizational unit responsible for development of courseware and other programs would be established. Delivery of CAI would be the responsibility of the user group and would be organizationally separate from a development unit. The second option would be for each local user to support both development and delivery, using the central facility simply as a communication device and a means of sharing courseware resources with other local users, and to accommodate central storage of common data.

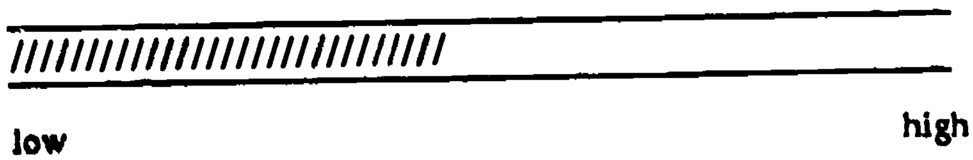
2.5. Procurement. In situations where it may be difficult to allocate a large amount of money at one time for CAI, a modular system can allow a small initial procurement without limiting the ability to expand into a larger CAI system at some future time. However, the license costs for the CAI software may be the same for the smaller unit as for the larger unit in the modular system. Thus, if you start off with a small configuration, you could easily find yourself paying more for the software than the hardware. In your procurement process, you should plan accordingly for the difference in cost between software and hardware. Also, price breaks often occur as the result of quantity purchases in both hardware and software; thus, quantity purchasing should be explored.

2. Modular Computer System Configuration

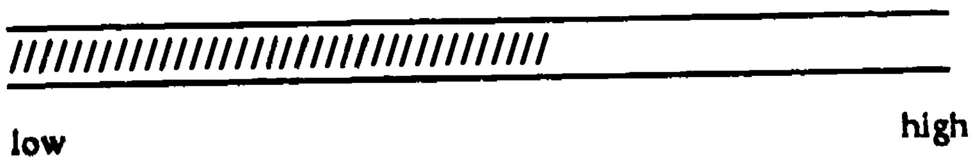
1. Purchase or start-up costs



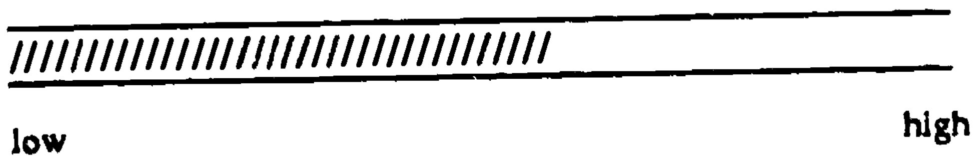
2. Communications cost



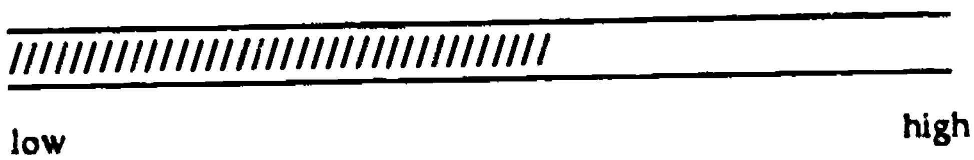
3. Operational costs



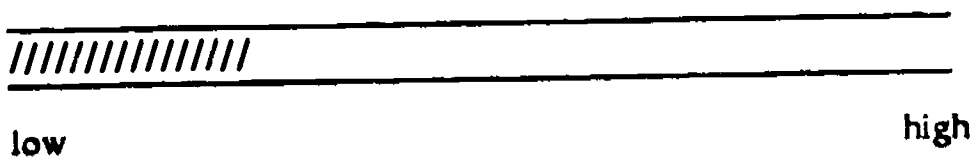
4. Maintenance costs



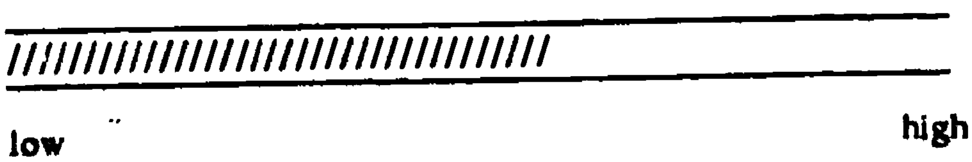
5. Amount of staffing



6. Need for special facilities



7. Relative organizational impact



B. CAI Computer Hardware

1. Stand-Alone Computer System Configuration

Section Technical Vocabulary[4]

main memory	processing time
hard disk	external storage
data bases	time-share
main memory	operating system

A stand-alone computer system configuration is illustrated in Figure III-3. The stand-alone computer system is distinguished from a modular-type system in that the basic computer used is designed solely to be a single-user computer. The basic computer unit in the modular-type system can function either as a single-user computer or a multiuser, multitasking computer.

The stand-alone system configuration is based on a collection of independent microcomputers. The microcomputers can be networked together to share common memory storage units such as a hard disk drive. Such a network of microcomputers can be distinguished from a central, time-shared system in that there is no single operating system software governing the availability of processing time, main memory, and external storage. Each microcomputer in the network is its own complete system. Each unit in the stand-alone network has to have its own complete set of operating software. However, the network feature, if present, does allow the sharing of CAI programs or data bases. Of late, several manufacturers of mainframe or minicomputer equipment have begun selling their own line of stand-alone microcomputers, which presently have or are expected to have hardware and software features that will allow them to operate either stand-alone or "on-line" to their larger mainframe or minicomputers. These capabilities will allow implementation of a full range of system configurations.

Some stand-alone microcomputers can be networked together to share a hard disk storage device. Some use a CAI capability based on an authoring language (see Section III.C.2) similar to that used by the PLATO System.

Advantages

The main advantage of a stand-alone CAI system is that it provides the lowest entry-level cost for hardware when the number of users is to be relatively low. A second advantage of the stand-alone system is that it can usually be

[4]See Glossary, Section V.B.

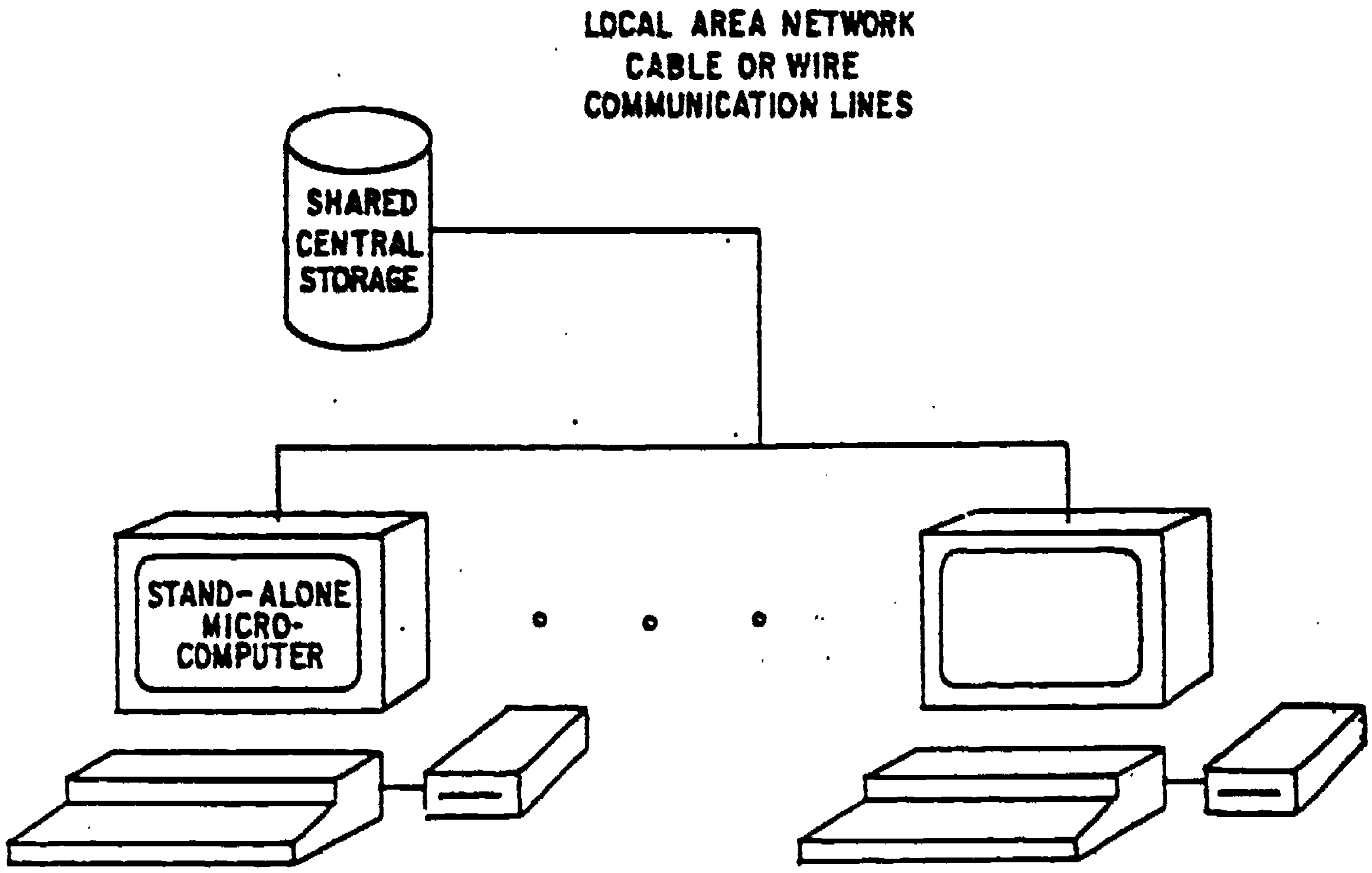


Figure III.3. Stand-alone, local network CAI system configuration.

adapted to provide unique dedicated instruction such as might be needed in the context of a special training device or peripheral. For both reasons, the stand-alone minicomputer is an excellent introductory tool for a small CAI demonstration.

Disadvantages

The capacity of the stand-alone system in terms of available main memory is often much less than that available in either a modular system or a large central system. Generally speaking, stand-alone systems based on popular, personal microcomputers lack the capacity to run very complex CAI programs nor can they be converted into CMI systems at a later date. For the instruction of large numbers of students in a single geographic or physical location, the redundancy of processing capacity, main memory, and operating software can be more costly than for modular or central systems.

Stand-alone systems do not, as a rule, offer the software tools that are available on either a central or a modular-type system. The lack of specialized CAI software development and revision tools is a function of memory and storage limitations in the stand-alone systems. Thus, courseware development can be more difficult and time-consuming with stand-alone systems.

3.1. Cost Requirements. The initial cost of the stand-alone system is generally the lowest of the three system configurations discussed in this handbook. However, not only short-term costs but long-term costs must be carefully considered. If a few stand-alone systems are acquired first, will these have to be expanded to support a larger number of students in the future? If so, what will the cost be using stand-alone equipment? If a larger system will be required in the near futufe, can the courseware developed for the stand-alone system be easily transferred to the larger system? If the stand-alone systems are adequate for immediate and future instructional needs, then the next cost consideration is whether a network capability is needed and whether moving to a CMI system is anticipated. In general, if there are 5 to 10 users, it is less expensive to have a network sharing common external storage.

3.2. Staffing Requirements. Stand-alone systems require minimum staffing for operation and maintenance. Stand-alone CAI systems are usually designed to be operated by the regular instructional staff. Staffing for CAI development is dependent upon available CAI development and revision tools.

3.3. Facility Requirements. Stand-alone systems do not require special facilities. They are designed to operate in a normal classroom environment.

3.4. Organizational Requirements. In general, stand-alone CAI systems will have the minimum impact on your existing organizational structure relative to other configurations. However, the ease with which these systems can be used may be misleading. If instruction is meant to be standardized, organizational mechanisms will be needed to ensure proper configuration management of the courseware and other application software. Stand-alone systems allow local users to make changes to lessons easily; however, such changes affect only the local user.

3.5. Procurement. The typical low cost of stand-alone systems allows them to be purchased quite easily. However, caution needs to be exercised so that, over a period of time, different groups within an organization have not purchased a variety of incompatible systems which preclude future sharing of courseware resources or development skills when a later level of CAI usage warrants it.

B. CAI Computer Hardware

3. Stand-Alone Computer System Configuration

1. Purchase or start-up costs

////////////////////////

low high

2. Communications cost

/////////

low high

3. Operational costs

/////////

low high

4. Maintenance costs

/////////

low high

5. Amount of staffing

/////////////////

low high

6. Need for special facilities

//////

low high

7. Relative organizational impact

/////////

low high

B. CAI Computer Hardware

4. Hardware Components

The computer system configurations discussed in Sectior- III.B.1, III.B.2, and III.B.3 all consist of four hardware components:

1. The computer processor.

2. External memory and storage devices.

3. Types of CAI terminals.

4. Communication system.

For any particular classification of hardware components, there is not necessarily a unique match between hardware type and a particular system configuration. For example, a central system configuration can have as its central computer a mainframe computer, a minicomputer, or a microcomputer. In assessing the level of hardware needed for a proposed CAI capability, each hardware component has to be given individual consideration apart from how it is configured in total.

B. CAI Computer Hardware

4. Hardware Components

4.1. Processor Size.

Section Technical Vocabulary[5]

processor
bit
"word"
time-share

The main component of a CAI system is the computer processor. Computer processors have come to be classified into three general types: mainframes, minicomputers, and microcomputers. These three classifications in the past have generally corresponded to the size of the computer processor. Size is measured by how much information, designated in bits, that the computer could process at one instant in time. This size designation in terms of bits of information is known as "word" length of the processor. Thus, a 32-bit word characterized a mainframe computer processor, a 16-bit word characterized a minicomputer processor, and an 8- or 4- bit word characterized a microcomputer processor. However, with the extremely rapid development of microprocessor technology, word length is no longer particularly accurate in distinguishing one level of computer processor from another. There are now microcomputers with processors that have 16-bit words as well as 8-bit words. The designation of size has to be made on a variety of factors; **across manufacturers there will be an overlap in the use of the terms mainframe, minicomputer, and microcomputer. For the purposes of this handbook, the primary factor of distinction will be the number of users easily supported by a single computer processor.**

4.1.1. Mainframe. The term mainframe computer refers typically to a large, multipurpose computer. Mainframe computers are used where heavy processing activities are required on a time-shared basis. Mainframe computers tend to be used where the number of users exceeds 100.

4.1.1.1. Cost Requirements. Mainframe computers tend to be costly. The average price range is between $150,000 and $5,000,000.

4.1.1.2. Staffing Requirements. Mainframe computers require a fairly large staff of system programmers and computer operators for their proper operation and maintenance.

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[5]See Glossary, Section V.B.

4.1.1.3. Facility Requirements. Mainframe computers normally require special facilities to maintain a proper environment for their operation. These facilities usually need to be air conditioned and wired to handle large electrical loads. Because of the large number of users on a mainframe at one time, the facilities usually include a back-up power supply system.

4.1.1.4. Support Capacity. Mainframe computers have the capacity to support a large number of users operating different programs at the same time. For CAI use, this means that one computer can be expected to support many courses at one time. A large mainframe computer can potentially support the entire CAI operations of a single training organization such as a training school or group.

4.1.2. Minicomputer. A minicomputer is a computer which has sufficient power to handle between 20 and 50 users. Some manufacturers sell what they consider a minicomputer that can handle more than 50 users; some, as high as 128 users. However, on the average, a minicomputer is a medium range machine.

4.1.2.1. Cost Requirements. The average cost for a minicomputer is between $20,000 and $200,000.

4.1.2.2. Staffing Requirements. Because of their smaller size, minicomputers typically do not require the level of maintenance that a mainframe computer does. Minicomputers usually do not require a staff of computer operators. For most minicomputer operations, one or two individuals can serve both as system programmer and system operator.

4.1.2.3. Facility Requirements. Minicomputers normally do not require special environmental conditions; however, they can be large enough that special electrical power requirements are needed. Minicomputers will put out a fair amount of heat, but normal room air conditioning is usually sufficient to offset this heat production.

4.1.2.4. Support Capacity. Minicomputers used for CAI can support several students working on different lessons at one time. However, if some of the lessons are processing-intensive such as is the case with instructional simulation, then other users may be affected. For special applications of CAI, such as intelligent CAI, a minicomputer which can normally handle 15 students would be able to handle only 2 to 4 students. For CAI applications, a minicomputer would usually be limited to supporting a single large course or several smaller courses. A minicomputer could support the CAI operations of a training branch.

4.1.3. Microcomputer. A microcomputer is typically small in size and is the type of computer which is often referred to as a personal computer or a desk-top computer. However, microcomputers can also come in floor-type cabinets and be as large as some minicomputers. A microcomputer is distinguished by the fact that its processing unit is in the form of a single electronic chip. Microcomputers are often designed for the single user, but some microcomputers can handle as many as 16 user terminals. Generally, a microcomputer is best suited for five or fewer users.

4.1.3.1. Cost Requirements. Microcomputers are relatively low cost devices. The price range for units useful for CAI is from $150 to $10,000.

4.1.3.2. Staffing Requirements. The average microcomputer has been designed to be operated by personnel without special computer training; however, for microcomputers which can support several users or for several, single-use microcomputers connected together into a communication network, it would be advisable to have at least one person who is a knowledgeable computer programmer.

4.1.3.3. Facility Requirements. Microcomputers require no special facilities. They can be easily operated in a normal classroom or office environment.

4.1.3.4. Support Capacity. Most available microcomputers for CAI are meant to support a single user taking a single lesson at a time. Some of the larger and newer microcomputers can support several students taking different lessons at the same time. These larger microcomputers can handle the CAI requirements of a single course or in some cases a training branch. Smaller microcomputers are best for the support of individual units within a course.

B. CAI Computer Hardware

4. Hardware Components

4.1. Processor Size

4.1.1. Mainframe

1. Cost

//

low high

2. Staffing requirement

//

low high

3. Facility requirement

//

low high

4. Support capacity

//

low high

4.1.2. Minicomputer

1. Cost

/////////////////////////

low high

2. Staffing requirement

/////////////////////////

low high

3. Facility requirement

/////////////////////////

low high

4. Support capacity

/////////////////////////

low high

4.1.3. Microcomputer

1. Cost

/////////

low high

2. Staffing requirement

/////////

low high

3. Facility requirement

//////////

low high

4. Support capacity

//////////

low high

B. CAI Computer Hardware

4. Hardware Components

4.2. Memory Storage.

Section Technical Vocabulary[6]

central memory	byte
read only memory (ROM)	bit
random access memory (RAM)	data files
external memory	hard disk
memory chip	floppy disk
megabyte	kilobyte

There are two classes of computer memory. Internal or central memory is that which is resident within the computer. External memory is that which resides outside of the computer. External memory itself can be classified into three distinct types: hard disk, floppy disk, and cartridge. All memory capacity is indicated in bytes of data or information which it can store. One byte is equivalent to 8 bits of information or a single alphanumeric character.

4.2.1. **Central Memory.** Central memory is hardware-based memory that is usually designated by the terms ROM (read only memory) and RAM (random access memory). ROM is memory which, once it has been created, cannot be changed. It is used to store permanent programs usually supplied by the manufacturer of the computer. RAM is memory that can be used to store programs temporarily while they are being processed by the computer. Most central memory is of the RAM type. Central memory should be contrasted to external memory, which is that memory storage capacity which resides outside of the computer itself.

4.2.1.1. Cost Requirements. Of all memory, central memory is the most expensive (in part because it is provided by memory chip hardware). For one line of popular minicomputers, a megabyte of central memory is approximately $9,000. This is $.009 per byte.

4.2.1.2. Support Capacity. The amount of central memory required is directly proportional to the number of users that the CAI system is to support and to the number of different programs that will be run at any single time. The type of CAI software that is available will make a big difference in the amount of central memory that is needed. If each CAI lesson is a self-contained program, then sufficient central memory will be needed to store each lesson so that it can

[6] See Glossary, Section V.B.

be processed in real time by the computer. An alternative is to have a CAI delivery program that operates on lesson data files. In this case, the delivery progam pulls in from external memory only that portion of a lesson which is needed at one time. The amount of central memory needed is that which provides for the delivery program and a certain amount of central memory "work space" for each user. Determining the amount of central memory that is needed is referred to as sizing a computer system.

4.2.2. Hard Disk. Hard disk is a form of external memory which provides for very rapid access of data. It consists of a stack of magnetic disks and pickup arms over each disk in the stack. The concept of a hard disk is like the record and the stylus arm of a phonograph. A hard disk is a stable storage environment and information on it is randomly accessible. Hard disks offer large amounts of relatively cheap memory storage. Most hard disks are integral to the device that reads them; however, there are some hard disk units which have removable disk units. For microcomputers and minicomputers there are typically two sizes of hard disk--5¼" and 8"--usually referred to as "Winchester type" disk drive. Large mainframe computers use larger type drives.

4.2.2.1. Cost Requirements. Small hard disk units typically used with microcomputers and small minicomputers average $2,000 to $5,000. Larger hard disk units associated with large minicomputers and mainframe computers average $8,000 to $20,000. For a popular series of minicomputer, a 28-megabyte hard disk with removable disk cartridge is $13,000. The memory cost per byte is $.00046. A 5-megabyte hard disk used with popular microcomputers costs approximately $3,800, or $.0008 per byte. As can been seen, there is a savings in buying larger increments of memory capacity.

4.2.2.2. Support Capacity. The capacity of smaller hard disk units (5¼") generally is available in increments of 5 megabytes up to a total of about 20 megabytes. Larger hard disk units (8") usually range from 40 megabytes to 160 megabytes. Hard disk units used with mainframe computers are usually 14" drives and can store as much as 1,800 megabytes of data. Assuming that one page of printed, single-space text is 4,752 characters (66 lines x 72 characters per line), then a 5-megabyte disk would hold 1,042 pages of printed text information. A 160-megabyte disk would hold 33,670 pages of printed information.

4.2.3. Floppy Disk. A floppy disk is a flexible, plastic, external memory storage device. Floppy disks come in two basic sizes--5¼" and 8". Unlike hard disks, the floppy disk is always separate from the mechanical drive that reads it. Floppy disks containing CAI courseware can be physically stored in cabinets, notebooks, etc. until they are needed. Floppy disks are physically handled during use; therefore, they are more subject to damage than are hard disks. Generally the life expectancy (the number of times they can be read before losing data) of floppy disks is less than that of hard disks. Floppy disks, like hard disks, can be both read and written to, and the data on them are randomly accessible. Floppy disks are usually limited to use with microcomputers and small minicomputers.

4.2.3.1. Cost Requirements. The cost of floppy disks is relatively low. The disks themselves cost an average of $3 to $8 each. The disk drives for the

5¼" disk average about $500 whereas 8" drives average about $900. For a popular personal microcomputer, the floppy disk drive costs $395 with a storage capacity of 140,000 bytes. This is a cost of $.003 per byte.

4.2.3.2. Support Capacity. Floppy disks which are 5¼" in size can store anywhere from 88 kilobytes to 1 megabyte. However, 5¼" drives used with personal-type microcomputers tend to have a capacity of 140 to 170 kilobytes of storage. This level of storage would hold 29 to 36 pages of printed text information. Eight-inch floppy disks typically store 256 kilobytes to 4 megabytes of data. This means a capacity of 54 to 842 pages of printed text information.

B. CAI Computer Hardware

4. Hardware Components

4.2. Memory Storage.

4.2.1. Central Memory

1. Cost Requirements

///

low high

2. Support Capacity

/////////////////////////

low high

4.2.2. Hard Disk

1. Cost Requirements

/////////////////////////

low high

2. Support Capacity

//

low high

4.2.3. Floppy Disk

1. Cost Requirements

///////

low high

2. Support Capacity

//////////

low high

B. CAI Computer Hardware

4. Hardware Components

4.3. CAI Terminals.

Section Technical Vocabulary[7]

CRT	intelligent terminal
flat panel	"dumb" terminal
RF	selective erase
RGB	time-share
pixels	terminal driver

There are several types of terminals which can be used for the presentation of CAI lessons. Stand-alone microcomputers that are classified as "personal" or "desk-top" units are really a computer and terminal in one package. For these types of computers, the terminal component is primarily the video display unit (or screen). For CAI systems based on minicomputer, mainframe, or larger microcomputers, separate, individual terminals have to be used to present CAI courseware. For purposes of delivering CAI, some level of graphics capability in the terminal is necessary. Graphic terminals can be classified by the type of display they use. One display type is based on the use of a cathode-ray tube (CRT). The other type is based on the use of flat panel technology which uses fluorescence, plasma, or electroluminescence to create an image rather than an electron beam and phosphor as in a CRT.

4.3.1. Video Display Units. The video display unit is used with stand-alone, single-user microcomputers for which a separate computer terminal is not required. The video display unit can be of two types--a normal black-and-white or color television or a video monitor. If the display unit is a monitor, the input from the computer goes directly to the video amplifier of the CRT without having to go through a radio frequency (RF) section, as is the case with a normal TV set. For this reason a monitor provides a crisper display than a TV.

There are two types of video inputs to a video display unit from the microcomputer. The first kind is a composite video input; for color-type displays this means that the three prime colors (red, green, and blue) components of a display are combined into a single input signal. The other type of video input to the video display unit is referred to as Red, Green, Blue (RGB), which means that the prime color components are input separately to the video amplifier of a video monitor. TV-type display units can have only a composite video input. RGB input provides better color display capability than does composite video input; however,

[7]See Glossary, Section V.B.

if the same monitor is to be used for both computer displays and normal video displays, then a composite input is needed.

4.3.1.1. Cost Requirements. The cost of a video display unit is equivalent to that of a good television set. The average use for CAI will require a 12" diagonal picture tube. Whether the unit is a regular TV or a composite video monitor, the price will be approximately $350 for color. For an RGB-type monitor, the average price will be about $800.

4.3.1.2. Support Capacity. The resolution of a TV-type display unit is approximately 192 by 256 pixels. The first number is the resolution in the vertical dimension while the second number indicates the resolution in the horizontal dimension. A pixel is a discrete point of illumination on the screen. The greater the number of pixels, the greater the resolution. The average number of text characters that can be displayed by a TV-type monitor is 960. An RGB-type monitor will have a typical resolution of approximately 240 x 560 and will be able to display 1920 text characters.

4.3.2. CRT Graphic Terminals. A CRT graphic terminal is used with computers that do not fall within the category of "personal" computers. A CRT graphic terminal is a self-contained unit with both keyboard and display. There are two ways to classify CRT graphic terminals. One way is on the basis of whether the terminal can support, on its own, any of the processing associated with a graphic image. If the terminal does support some of the image processing, then it is classified as an "intelligent" terminal. If it does not, then it is a "dumb" terminal.

The other way CRT graphic terminals can be classified is on the basis of how they produce a graphic image. One way an image is produced is called "raster scan." This is the method used by a television set to produce an image. Another method of image production is called "storage tube." In a storage tube-type terminal, the electron beam is controlled so that it literally "paints" the image on the screen as if one were using a pen. Additionally, once the image is drawn in a storage tube-type terminal, the image tends to remain in view rather than immediately disappearing and thus having to be redrawn. In the raster scan terminal, the electron beam simply scans back and forth, top to bottom, turning pixels on and off as it moves back and forth. The image produced by a raster scan terminal has to be constantly redrawn or refreshed. A storage tube display will draw complex curves very precisely but slowly. A raster scan display will draw a curved image very quickly but it will be more jagged in appearance. Finally, a third type of graphic display capability is called "vector refresh." It draws an image on a point-to-point vector basis like a storage tube device, but the image is constantly refreshed as in a raster scan display. A vector refresh device can provide a precise image fairly quickly. Most vector refresh graphic terminals lack color capabilities.

4.3.2.1. Cost Requirements. The average price for "dumb" terminals is approximately $1,000. Intelligent-type graphic terminals average $2,500 to $3,500 with high resolution, with special function terminals being as high as $10,000 to $15,000. Storage tube-type CRT terminals are generally less expensive than raster scan-type terminals. However, the maintenance and replacement costs for storage tube-type terminals are higher than for raster scan-type terminals. Except for TV-quality raster scan displays, the cost of raster scan and vector refresh displays is higher for a high-resolution capability because they need more complex refresh circuits.

4.3.2.2. Support Capacity. Two things should be considered in selecting a terminal for a CAI application. The first is the resolution of the image, and the second is the speed with which a complex image can be produced. Relatively inexpensive raster scan-type terminals are good in CAI applications where text is used primarily and the graphic images are not overly complex. Also raster scan provides good quality color and brightness. In areas of CAI, such as simulation where good resolution of equipment components or schematics is needed, the vector-based drawing of a storage tube or vector refresh device is better than the point-by-point or character graphics addressing of a raster scan device.

Where speed is important, such as in frequently changing graphic displays, or where the part of the display is being selectively erased and new information is being presented, a raster scan device is a good choice, as long as the graphics are not too complex. The speed with which a graphic terminal will draw a new display is dependent on whether the terminal has any "intelligence." In a time-shared system, the terminal driver (software which controls what the terminal will do) can control the creation of a display. However, this is usually slower than if control data are sent to an intelligent terminal which itself has an internal program that produces the display image. The tradeoff is one of cost versus speed.

4.3.3. Flat Panel Display Terminals. A flat panel display consists of two panels of glass which have sandwiched between them a grid of conductors and an inert gas. When an electrical charge is placed at a point in the conductor grid, the gas is caused to glow, producing a point of illumination. The most notable aspect of flat panel displays is their compactness. Additionally, flat panel displays are very rugged compared to CRTs. The PLATO system previously used a plasma panel display as its primary terminal. Lately, CRT-type terminals are being more frequently used with PLATO. Flat panel displays are limited to being monochromatic. In addition to a plasma panel, a flat panel type which is appearing more and more in handheld or portable computers is the liquid crystal display (LCD). Although handheld devices have not typically been used for CAI, they do have the potential for use, especially as low-cost drill-and-practice or testing devices.

4.3.3.1. Cost Requirements. The cost of flat panel technology is generally expensive. The flat panel itself, apart from the rest of the terminal hardware, is typically 8 to 10 times more expensive than is a CRT with comparable resolution. A CRT by itself may cost $100 whereas a comparable flat panel costs $2,500. LCDs are inexpensive because they are kept small in size and are mass produced. A typical handheld computer is $250 to 400.

4.3.3.2. Support Capacity. The plasma-type flat panel display and terminal typically provide a resolution of 512 x 512 pixels. In the PLATO system this produces a text display of 2,048 characters. Also, with a plasma display it is possible to display various sizes and types of characters as well as rotate characters. Very small characters maintain their readability. One reason the early PLATO system used a plasma-type display was that it easily maintains a display image. In other words, the display has its own memory and does not have to tie up computer memory to maintain the representation of an image. An intelligent CRT-type terminal accomplishes the same thing by having its own display and computer memory. A reduction in computer memory chip prices reduced the memory advantage of the plasma panel. Another advantage of the plasma display which was seen as being useful was that a film-based image could be projected onto it from the rear. This allowed high-resolution film images to be used with computer graphics. Liquid crystal displays, as they appear in handheld devices, provide only limited displays of either text or character graphics. The size of the typical LCD is one to four lines of 40 characters. An LCD can be used as a "window" onto a larger body of text through scrolling both right and left as well as up and down.

4.3.4. Other Terminal Features. In addition to the type and the resolution of the display chosen, consideration has to be given also to the input feature of a terminal. The most common input mode is the keyboard. However, keyboards can range from simple typewriter-style layouts to more complex configurations, which include separate numerical keypads or special function keys.

For CAI, the availability of function keys can be very important to the support of certain instructional strategies. For those approaches which allow learner access to specialized information, it is desirable that this information be accessed with a single key stroke.

Other terminal input modes which should be considered include touch panels or light pens, which can allow a student to respond by simply pointing to a screen location. It is desirable that terminals used in support of CAI allow access to such alternative input modes. On lower cost microcomputers, it is often the case that the game I/O port can be used with a joystick or a "mouse" to move a cursor around in order to allow the student to indicate a response.

B. CAI Computer Hardware

4. Hardware Components

4.3. CAI Terminals

4.3.1. Video Display Units

1. Cost Requirements

//////////////////

low high

2. Support Capacity

//////////////////

low high

4.3.2. CRT Graphic Terminals

1. Cost Requirements

(dumb terminal)

//////////////////

low high

(intelligent terminal)

//

low high

2. Support Capacity

(raster scan)

/////////////////////

low high

(storage tube/vector refresh)

//

low high

B. CAI Computer Hardware

4. Hardware Components

4.3. CAI Terminals

4.3.3. Flat Panel Display Terminals

1. Cost Requirements

low high

2. Support Capacity

low high

4. Hardware Components

4.4. Communications.

Section Technical Vocabulary[8]

modem
dedicated/unloaded telephone lines
baud rate
acoustically coupled modem
direct connect modem
multiplexer
star network
ring network
data packets
communication protocol

Whether the CAI system to be adopted is a time-shared central computer system, a modular computer system, or a network of stand-alone computers, some form of communication system will be needed to allow various users (students and instructors) to communicate with the computer and with each other. The type of communication system used can be characterized by the mechanism of data transmission within the system. On this basis, there are three types of communication systems pertinent to the typical use of a CAI system. The first type centers on the use of dial-up, telephone modems. The second type uses dedicated telephone lines, and the third type uses cable or twisted wire lines within a building or between buildings that are close together.

An important measure of the capability of a communication device or system to transmit data is the "baud rate." The baud rate determines how much and how fast data can be transmitted between a terminal and a computer, or between two computers. The higher the baud rate, the faster a CAI system can respond to the inputs of a student.

4.4.1. Dial-Up Modem. The dial-up modem is a device that will allow a telephone and/or a voice-grade telephone line to be used to transmit CAI lessons or data between the computer and its terminals, or between computers. There are basically two types of dial-up modems. One is an acoustically coupled modem and the other is an auto-dial, direct-connect modem. The first requires the user to manually make a connection to the computer by dialing a telephone access

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[8]See Glossary, Section V.B.

number and then physically placing the telephone receiver on connecting ports of the modem. The second type is connected between the telephone and the telephone line and automatically "dials" the computer through commands from the terminal.

4.4.1.1. Cost Requirements. Dial-up modems are fairly inexpensive. Acoustic modems average about $120, and auto-dial modems average about $250. Communication costs associated with charges from the telephone company can be kept low because the telephone lines are being used only when they are needed (not dedicated lines).

4.4.1.2. Support Capacity. Acoustic modems generally transmit data at 300 or 1,200 baud. At 300 baud it will take approximately 26 seconds to transmit 1,000 characters. At 1,200 baud it will take approximately 7 seconds to transmit the same 1,000 characters. An auto-dial modem typically transmits data at rates between 1,200 baud and 9,600 baud. However, typically 1,200 to 4,800 baud is all that can be expected with voice-grade lines. At 4,800 baud, it takes approximately 2 seconds to transmit 1,000 characters. Low baud rates make it difficult to provide CAI with a great deal of graphics except for character-based graphics. Additionally, slow response time during student-terminal interaction can be distracting and irritatingly slow. Voice-grade line transmission of data is the most subject to interference. However, with voice-grade lines and dial-up modems, users of a CAI system can be anywhere in the country where telephone service is provided.

4.4.2. Dedicated Telephone Lines. A dedicated telephone line allows users to be permanently connected to a computer. Because the telephone line is dedicated to one user, such quality of transmission can be upgraded. Such telephone lines are usually referred to by the telephone company as conditioned or unloaded lines. With a dedicated line, a device called a multiplexer is normally installed to allow more than one terminal to use the dedicated line. A typical multiplexer would allow up to eight terminals to use a single dedicated line, helping to keep communications costs as low as possible.

4.4.2.1. Cost Requirements. The biggest cost associated with the use of a dedicated line is the cost of renting the telephone line from the telephone company. This cost varies with the distance between the computer and the users, but can run over $1,000 a month for very long distances. A multiplexer will cost approximately $2,000 to $5,000 and will vary with the number of users supported.

4.4.2.2. Support Capacity. The transmission rate over a dedicated line can usually be higher than transmission rates over voice-grade lines. With a dedicated line, baud rates of 9,600+ are possible. At 9,600 baud, it would take approximately 1 second to transmit 1,000 characters. Dedicated lines have less interference associated with them.

4.4.3. Local Network. The local network consists of a system of coaxial cables or regular, twisted pair lines (telephone wire) which connect computers and/or terminals together at a single, geographic site. There are basically three types of local network configurations: hierarchical, star, and ring. In the hierarchical network, a central computer communicates with intermediate-level computers down to the user level. In a training organization, a hierarchical network would be one where a central computer is at the training base level and communicates with computers at the training group or branch level. In a hierarchical system, communication between intermediate-level units has to pass through the central computer first. In a hierarchical network, interunit communications can be tightly controlled.

In a star network configuration, a central unit communicates directly to the user units connected to it. The user units and their communication lines can be visualized as radiating out from the central unit in a star pattern. As new units are connected into a star-type network, a new communication line is connected for each new unit.

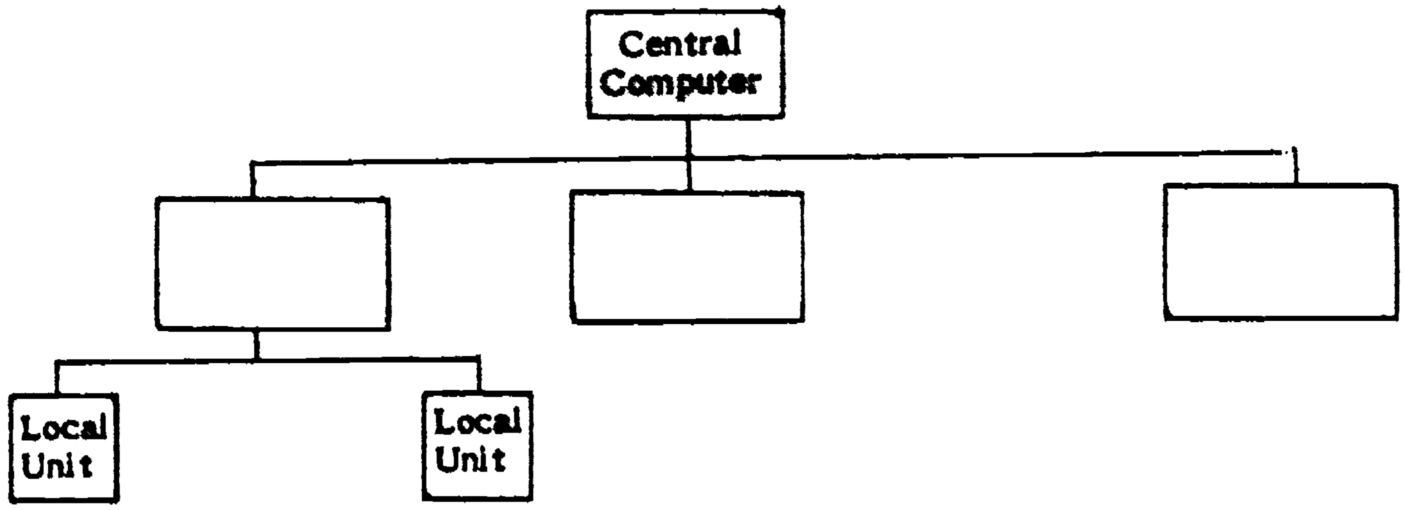
In a ring network configuration, a single cable or bus is strung around the facility. All units are connected to this bus and can communicate in an equal fashion to all other units on the bus. In a ring type of system, the bus is put in place and units are connected to it as needed. The units that are connected can be terminals, computers, memory storage units, etc. A ring type of network is very democratic in that all units connected are accessible. See Figure III-4 for diagrams of the three network configurations.

4.4.3.1. Cost Requirements. For a ring type of system, the complete network is usually put in place at the beginning even though a full complement of users will not be connected right away. A ring network also is based on the use of cable and sophisticated electronics which sort out the "data packets" from the separate users to ensure that data are transmitted to the proper place.

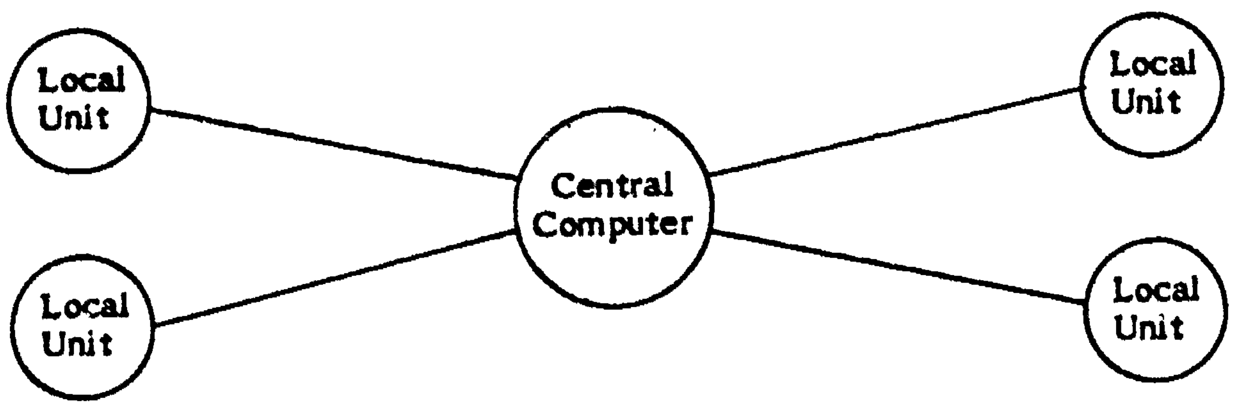
A star-type network is frequently based on twisted wire pairs, which are less expensive than coaxial cable; however, for every unit in the network a separate communication line is needed. The communication protocol (the determination of when each unit communicates) is handled by the central unit in the system. This usually requires less costly electronics than for a ring-type network.

A hierarchical network usually combines a cable system with twisted wire pairs. Intermediate-level units (i.e., computers) are connected to a more remote central unit by cable while local terminal-type units are connected to the intermediate unit via twisted wire pairs.

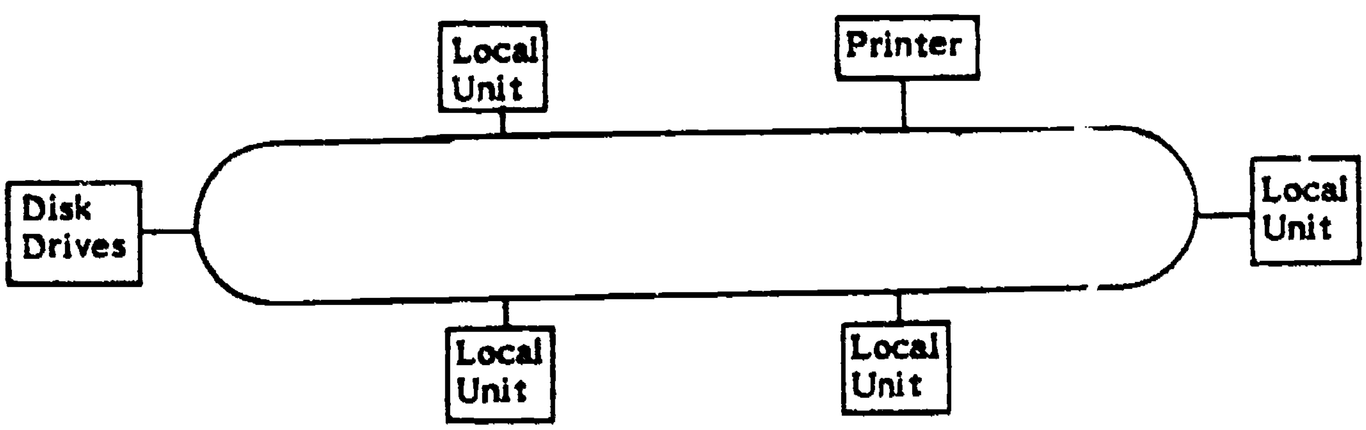
4.4.3.2. Support Capacity. In a star-type network, the number of users is determined by the number of communication ports available on the central unit. For a ring type of system, the number of users is determined by the sophistication of the communication electronics of the network. In a hierarchical network, the number of users is a function of the number of communication ports that exist at each level within the hierarchy.



a. Hierarchical Network



b. Star Network Configuration



c. Ring Network Configuration

Figure III-4. Three network configurations

B. CAI Computer Hardware

4. Hardware Components

4.4 Communications

4.4.1. Dial-Up Modem

1. Cost Requirements

//////

low high

2. Support Capacity

///////////////////

low high

4.4.2. Dedicated Telephone Lines

1. Cost Requirements

///

low high

2. Support Capacity

///

low high

4.4.3 Local Network

1. Cost Requirements

///////////////////////////

low high

2. Support Capacity

///

low high

C. CAI Software Support

1. Higher Order Languages

A higher order language (HOL) is a general-purpose computer language that can be used for a variety of applications, including the development of CAI courseware. Examples of popular HOLs are BASIC, FORTRAN, Pascal, and COBOL. An HOL represents a very fundamental way of communicating instructions to a computer. However, because an HOL has to serve a variety of users and their applications, the commands to be found in them have to be general purpose; thus, there will be no commands peculiar to CAI applications. CAI courseware developed in an HOL will be stored as a computer program; thus, each lesson developed will be a separate computer program. Figure III-5 illustrates a simple multiple-choice question that can be found in a CAI program. Figure III-6 shows how this question would have to be programmed using the BASIC HOL.

1.1. Cost Requirements. HOLs represent the smallest capital investment of all the CAI software support types because most hardware manufacturers include at least one HOL as part of the system that they sell. Almost all personal-type microcomputers come with a form of BASIC programmed into ROM (read only memory) within the computer. However, in terms of recurring costs, HOLs can be very expensive because they require the most time to develop good CAI courseware. Also, HOLs require special programming staff in order to be properly utilized.

1.2. Staffing Requirements. The successful use of HOLs for the development of good CAI courseware requires the use of knowledgeable computer programmers. Simple informational, drill-and-practice, and tutorial CAI can be accomplished by instructional staff willing to take the time to learn an HOL; however, any CAI which involves more than rudimentary graphics and/or branching strategies will require professional programming skills.

1.3. Training Requirements. If the instructional staff is expected to use an HOL for the development of CAI courseware, then that staff will have to receive extensive training in computer programming. It is not advisable to train instructional personnel in computer programming unless the personnel are to be part of a long-term and stable development group.

1.4. Organizational Requirements. The proper use of an HOL for CAI development requires the establishment of a courseware development team. Such a team consists of at least two types of individuals: an instructor/subject-matter expert and a computer programmer. However, unless the instructors are knowledgeable in CAI instructional strategies and design, it is also recommended that the courseware team have an instructional design person as a member.

Because programming in an HOL can involve a great deal of time and effort, changes and revisions in the instructional design of a CAI lesson needs to be kept to a minimum once programming is initiated. Organizationally, proper review procedures must be in place to ensure that most content and design problems are worked out prior to programming.

Simple Embedded Question

A yellow light means:

1. Speed up
2. Stop
3. Slow down

Figure III-5. Sample multiple-choice question

The Question as a Sequence of BASIC Code

```
10     VTAB (10): HTAB (4)
20     PRINT "A YELLOW LIGHT MEANS"
30     VTAB (13): HTAB (9)
40     PRINT "1) SPEED UP"
50     PRINT: HTAB (9)
60     PRINT "2) STOP"
70     PRINT: HTAB (9)
80     PRINT "3) SLOW DOWN"
90     INPUT ANS%
100    IF ANS% = 1 THEN GOTO 1000
110    IF ANS% = 2 THEN GOTO 1000
120    IF ANS% = 3 THEN GOTO 1010
200    REM: REST OF PROGRAM: STEPS 210-900
1000   VTAB (23): HTAB (1): PRINT "NO THAT IS WRONG"
1001   GOTO 200
1010   VTAB (23): HTAB (1): PRINT "RIGHT"
1011   GOTO 200
```

Figure III-6. Multiple-choice question coded in BASIC

1.5. Support Capacity. An HOL provides the greatest amount of flexibility in creating CAI because the commands in an HOL represent the fundamental building blocks of any computer program. Also, a CAI lesson developed in a properly chosen HOL can be transported to different computers which use the same version of the HOL. CAI lessons developed in an HOL should represent stable areas of instruction because later modification of such lessons can be difficult, especially if different programmers are involved and sufficient care has not been taken to document the lesson program. If CAI lessons involve extensive and unique types of simulation, an HOL may represent the only effective means for accomplishing the development of such lessons.

C. CAI Software Support

1. Higher Order Languages

1. Purchase or licensing cost

/////////////

low — high

2. Staffing requirements

/////////////

current instructional staff	instructional staff with some programming	professional programmers

3. Training requirements (staff)

//

low — high

4. Organizational requirements

//

low — high

5. Support capacity (of CAI development)

//////////////////

low — high

6. Relative efficiency of courseware development

//////////////////

low — high

7. Relative amount of CAI development time required

//

low — high

C. CAI Software Support

2. Authoring Languages

An authoring language is a special-purpose computer language specific to the development of CAI. The command structure of an authoring language is specific to the instructional functions that are necessary to present text or graphics, accept student input, evaluate student input, and branch program control based on the input made. Different authoring languages achieve these basic instructional functions to varying degrees of complexity. CAI lessons developed via an authoring language are separate computer programs. The advantage of an authoring language over general-purpose computer languages is that each command provides a discrete instructional capability which would take several commands in a general-purpose language to accomplish. Figure III-7 represents the programming of the multiple-choice question shown in Figure III-5 as accomplished via the authoring language PILOT. The programming of the same question as accomplished in TUTOR (the authoring language of PLATO) is shown in Figure III-8. Other authoring languages are TICCIT Authoring Language (TAL), USE (a TUTOR-like language for the Regency CAI system), and DEC Authoring Language (DAL). The Air Force's AIS uses Computer Assisted/Managed Instructional Language (CAMIL). CAMIL is a special HOL that has ALGOL- and Pascal-like features but has a structure conducive to the development of CAI and CMI data bases and programming editors.

2.1. Cost Requirements. All authoring languages with the exception of the Air Force's CAMIL are proprietary and involve the cost of licensing their use. The licensing cost of an authoring language is considerably more than that associated with a general-purpose HOL. In evaluating the possible adoption of an authoring language, close attention should be paid to whether licensing costs involve a one-time charge or are based on some increment of the time the language is being used. Also, licensing may occur on the basis of a using site or organization regardless of the number of individual copies being used, or the licensing may be based on the number of individual copies used.

2.2. Staffing Requirements. It is possible for an instructional staff to use an authoring language such as PILOT which has a few basic commands to develop drill-and-practice and tutorial instruction. However, with more sophisticated authoring languages such as TUTOR, that has several hundred commands, the level of application programming skill required can become very high. Generally, a staff of specialized personnel knowledgeable in the authoring language will be needed to code the lesson materials developed by SMEs and instructors as represented in storyboard form. Staff personnel who code CAI lessons using an authoring language need not be computer programmers but will require specialized training in and experience with the authoring language.

2.3. Training Requirements. Most authoring languages allow two levels of application. At the novice level of application, instructor personnel can learn a relatively small subset of commands that will allow them to develop some basic CAI lessons. For an expert level of performance with an authoring language, time

The Question in Apple PILOT

```
*PART 1
T:   A YELLOW LIGHT MEANS
T:
T:   1) SPEED UP
T:
T:   2) STOP
T:
T:   3) SLOW DOWN
A:
MJ:  1
T:   NO, THAT IS WRONG
J:   PART 2
MJ:  2
T:   NO, RED MEANS STOP
J:   PART 2
MJ:  3
T:   YES, THAT IS CORRECT
*PART 2
```

Figure III-7. Multiple-choice question coded via the authoring language PILOT

The Question as a Sequence of TUTOR Code

```
UNIT TRAFFIC
WRITE A YELLOW LIGHT MEANS
         1) SPEED UP
         2) STOP
         3) SLOW DOWN

ARROW 501
ANS    1
JUMP   BD7
ANS    2
JUMP   BD11
ANS    3
JUMP   BD9
```

Figure III-8. Multiple-choice question coded via the authoring language TUTOR and experience are needed to become proficient with the full power of the authoring language.

2.4. Organizational Requirements. The use of an authoring language will simplify the production of CAI as compared to the use of an HOL; however, the extensive development of CAI, even with the use of an authoring language will require the establishment of a dedicated group of development personnel. A team approach to development is advisable, with instructional personnel and SMEs storyboarding a lesson, which then is turned over to coders who are expert in the use of the authoring language.

2.5. Support Capacity. An authoring language will provide for more efficient production of CAI lessons. For a start-up CAI development effort, the use of an authoring language, as compared to an HOL, can reduce the development time by as much as 60 percent. Also, the revision and maintenance of developed lessons is significantly enhanced by the use of an authoring language. To some degree, a good authoring language can be self-documenting.

C. CAI Software Support

2. Authoring Languages

1. Purchase or licensing cost

//////////////////////////////////

low — high

2. Staffing requirements

(middle of scale) ///////////////////

current instructional staff	instructional staff with some programming	professional programmers

3. Training requirements (staff)

///////////////////////////

low — high

4. Organizational requirements

///////////////////////////////////

low — high

5. Support capacity (of CAI development)

//

low — high

6. Relative efficiency of courseware development

/////////////////////////////

low — high

7. Relative amount of CAI development time required

/////////////////////////////

low — high

3. Authoring Systems

An authoring system uses a courseware development approach that does not require computer code generation as part of the instructional development process. Rather, an authoring system primarily involves the use of editors which contain a series of menus, prompts, and help sequences. These editors elicit information from the "author" of a CAI lesson, based on the instructional function to be performed. Using the multiple-choice example of Figure III-5, a typical authoring system would allow an author to enter the text of the question by simply typing it on the screen in the location desired. After the text of the question is entered, the authoring system would then elicit information via a prompt asking which question alternative is the correct answer and where in the lesson the students should go if they answer either correctly or incorrectly. An example of an authoring system editor display is shown in Figure III-9, from the Air Force's CASS Authoring System. An authoring system will often consist of several different types of editors corresponding to specific lesson-generation activities such as creating lesson graphics or producing a lesson menu page. Other examples of existing authoring systems are the WISE Authoring System, Professional Authoring Support System (PASS), The Authoring Procedure for TICCIT (APT), and PCD1 (PLATO Course Development). (PCD2 is expected to be available shortly.) In addition to the CASS Authoring System, the same contractor has developed an authoring capability called SID, a simulation development authoring capability.

3.1. Cost Requirements. Authoring systems are very powerful and complex development tools. As a consequence, their development required an extensive investment by the companies which provide them. The licensing fees for authoring systems can cost as much as the hardware on which they will run (exception is government-owned software such as CASS). Front-end licensing costs will approximate $5,000 to $60,000. Additionally, there will be yearly maintenance charges for maintaining the currency of the authoring system. An authoring system dramatically improves the efficiency of the CAI courseware development process; thus, the costs of courseware development and maintenance are significantly reduced.

3.2. Staffing Requirements. The use of an authoring system can eliminate the need for specialized staff consisting of coders or computer programmers. The editor-based approach of an authoring system permits instructional personnel to author their own lessons directly. However, for large courseware development projects, some efficiency is still gained by having certain staff personnel specialized as lesson authors even with the use of an authoring system.

3.3. Training Requirements. The use of an authoring system requires the least amount of training. The effective use of an authoring system can usually be gained in 1 week whereas from 2 or 3 weeks to as long as 1 year are needed for the effective use of an authoring language. The criterion being applied

FRAME 5: QM1 INSERT MODE 7.Lines

1. This is a sample multiple-choice question with
2. THREE alternatives.
3.
4. 1. This is alternative one.
5.
6. 2. This is alternative two.
7.
   3. This is alternative three.

Options: Enter multiple-choice question alternatives.
Press NEXT to end each line.
A line with no material (just a NEXT key) will allow question alternative entries.
COPY keys copy previous line.
Press BACK when finished.

Figure III-9. Completed multiple-choice question in each case is the capability to creatively use the majority of the CAI functionality provided by the authoring system or language.

3.4. Organizational Requirements. Because an authoring system can be effectively and quickly used by regular instructional personnel, it imposes the least demand on the establishment of unique organizational structures to accommodate the courseware development process. An authoring system is the best choice when CAI courseware has to be integrated into the work environment as an additional duty of the instructional staff.

3.5. Support Capacity. An authoring system provides a highly efficient means of CAI courseware production. The use of an authoring system generally requires only one-quarter of the time it takes to develop CAI using an HOL and approximately half the time it takes using an authoring language. The maintenance of existing courseware is highly improved with an authoring system because the recorded inputs for each editor menu represent an on-line form of documentation of exactly what was done to create the lesson. Though an authoring system is very efficient for the production of courseware, it can also be limiting to the degree that the format and options provided in its editors limit the use of certain instructional strategies.

Another aspect of an authoring system is that the lessons developed are represented as a data base rather than as a computer program. Most authoring systems consist of two separate programs. The first program is an author program that leads the author through the creation of a lesson data base. The second program is a delivery program that reads the created data base and conveys it as a lesson on the student's terminal. The advantage of this is that the authoring and delivery processes can be separated. Authoring usually requires a more sophisticated set of hardware than does delivery. Thus, with an authoring system, lower cost hardware can be bought for the delivery systems that have to exist in larger quantities than the systems used for authoring. Another advantage of the data base structure of an authoring system is that developed components of existing lessons can usually be conveniently borrowed and incorporated into new lessons being developed.

C. CAI Software Support

3. Authoring Systems

1. Purchase or licensing cost

//

low | high

2. Staffing requirements

//////////////////

current instructional staff | instructional staff with some programming | professional programmers

3. Training requirements (staff)

///////////////////////

low | high

4. Organizational requirements

///////////////////////

low | high

5. Support capacity (of CAI development)

///

low | high

6. Relative efficiency of courseware development

///

low | high

7. Relative amount of CAI development time required

//////////////////////////

low | high

C. CAI Software Support

4. Design Systems

A design system is a fairly new concept and is an extension of the principles underlying an authoring system. An authoring system focuses on the provision of capabilities that permit instructional personnel to readily manipulate the presentation and control capabilities of a CAI computer system. Though an authoring system makes it easy to program text and graphics and branch the learner from one lesson segment to another, it does not usually provide explicit guidance as to the design of a lesson. In this sense, authoring languages and authoring sytems can be considered design free even though they may constrain the use of certain instructional strategies. **A design system is a set of computer-based editors that lead a content expert through a systematic design process. A design system can either be a separate set of procedures or be an integral part of an authoring system. In either case, a design system is based on an explicit model of the learning and/or instructional process.** The editors of a design system seek information from a content expert or instructor on the basis of the learning or instructional model used. The Authoring Procedure for TICCIT (APT) is an example of a design system implicit in an authoring system. The Air Force's Training and Performance Support System (TPSS) provides an example of a design system separate from the authoring system. Design systems themselves are currently being designed and are expensive. More affordably priced systems are expected to be available in the next few years.

4.1. Cost Requirements. The concept of design systems is still developing; thus, there are limited cost data. However, commercially available design systems should have software licensing costs similar to those for authoring systems. The use of design systems should further reduce the costs of producing new CAI courseware.

4.2. Staffing Requirements. The use of a design system will enable instructor/content experts to systematically organize the content of a lesson, course, or curriculum on the basis of a learning model and/or instructional model appropriate to the capabilities of a CAI system and the knowledge and skills underlying an area of instruction (i.e., management training, electronics troubleshooting, mathematics, etc.). The use of a design system should reduce the number of specialized staff personnel required to develop and maintain CAI courseware.

4.3. Training Requirements. The production of good CAI by the typical instructional staff normally requires that that staff be trained in the detailed nature of CAI design strategies appropriate to different areas of instruction. The use of a design system, if available, permits the instructional staff to engage more quickly the CAI development process in an effective manner.

4.4. Organizational Requirements. The use of a design system minimizes the requirement for the establishment of specialized CAI development staff apart from the normal instructional staff required to conduct training.

4.5. Support Capacity. The typical development of CAI courseware requires three areas of expertise. The first area is content expertise. The second is instructional design, and the third is programming. Authoring languages and systems function to provide systematic support for the instructional staff, enabling them to program CAI lessons. A design system likewise provides systematic support to the instructional staff, enabling them to design CAI courseware more appropriately. In considering the adoption of a CAI system which may have an embedded design system, one needs to judge the appropriateness of the learning and/or instructional models it uses for the intended training. Independent design systems can be used with either authoring systems or languages to effect the programming of CAI courseware.

C. CAI Software Support

4. Design Systems

1. Purchase or licensing cost

//

low high

2. Staffing requirements

////////////////

current instructional staff	instructional staff with some programming	professional programmers

3. Training requirements (staff)

/////////////////////

low high

4. Organizational requirements

/////////////////////

low high

5. Support capacity (of CAI development)

//

low high

6. Relative efficiency of courseware development

//

low high

7. Relative amount of CAI development time required

//////////////

low high

D. Courseware

1. Informational CAI

Informational CAI is used as an adjunct to or in support of the primary instructional delivery (e.g., the instructor, programmed text, tutorial CAI). The information is usually stored in the computer as a data base of individually addressable nodes or frames of either text alone or of text and graphics. This form of CAI is a particularly good choice for in-house development because it requires minimal skill with computers and instructional sequencing. Therefore, with the widely available authoring aids, an instructor or other subject-matter expert could develop or revise informational CAI quickly. A further description of informational CAI is provided in Section II.D.

D. Courseware

1. Informational CAI

1. Overall complexity of development

//////////////

simple — complex

2. Relative cost of development and revision*

//////////////

low — very high

3. Relative level of organizational impact*

//////////////

minor — major

4. Staffing requirements for development and revision

/////////////////

conventional staff — trained conventional staff — trained CAI staff

*Relative to other forms of CAI.

2. Drill-and-Practice

Drill-and-practice allows the opportunity for enhanced learning through repeated practice on both knowledge- and performance-level instructional tasks. Two general categories or levels of drill-and-practice are described below. They require different levels of resources and provide different levels and types of instructional and institutional benefits.

Level 1: Nonadaptive. Nonadaptive drill-and-practice is the presentation of questions about factual information, concepts, and procedures. The sequence is fixed (i.e., not generated based on past or current student performance data). This is a good candidate for in-house development because some development aids are available and because it requires relatively few resources.

Level 2: Adaptive. Adaptive drill is a form of practice similar in content to Level 1 but, in addition, it takes into account past and current student performance data in the selection of practice problems, in the amount and type of feedback, and sometimes in the form of remediation, if any. This is a more complex type of CAI, requiring more specifically trained personnel who can make design decisions about program sequencing and feedback. This is a good candidate for in-house development if trained development personnel are used. Sophisticated authoring tools are not widely available, but authoring languages exist to support development of adaptive drill-and-practice. A further description of drill-and-practice is provided in Section II.D.

D. Courseware

2. Drill-and-Practice

	Level 1: Nonadaptive			Level 2: Adaptive	

1. Overall complexity of development

Level 1: Nonadaptive		Level 2: Adaptive	
//////////////		//////////////	
simple	complex	simple	complex

2. Relative cost of development and revision*

Level 1: Nonadaptive		Level 2: Adaptive	
//////////////		//////////////	
low	very high	low	very high

3. Relative level of organizational impact*

Level 1: Nonadaptive		Level 2: Adaptive	
//////////////		//////////////	
minor	major	minor	major

4. Staffing requirements for development and revision

Level 1: Nonadaptive			Level 2: Adaptive		
//////////			///////////		
conventional staff	trained conventional staff	trained CAI staff	conventional staff	trained conventional staff	trained CAI staff

*Relative to other forms of CAI.

D. Courseware

3. Tutorial CAI

Tutorials present instruction, providing direct instruction and taking the place of other forms, such as programmed text, instructors, etc. They usually consist of text and graphic explanations and are typically interspersed with embedded questions. Interactivity usually consists of the embedded questions, feedback, branching, and some learner control over help sequences and flow through the lesson.

The development of sound tutorial CAI is dependent on a skilled development staff; in-house tutorial CAI development is recommended if such staffing is available. There are some authoring tools available that can be quite helpful. The more sophisticated the tool (authoring or design system), the more conventionally skilled the development staff can be. A further description of tutorial CAI is provided in Section II.D.

D. Courseware

3. Tutorial CAI

Developed Using Programming or Authoring Languages	Developed Using Authoring or Design Systems

1. Overall complexity of development

Developed Using Programming or Authoring Languages	Developed Using Authoring or Design Systems
////////////////////////////	//////////////
simple — complex	simple — complex

2. Relative cost of development and revision*

(personnel costs)	(authoring aids costs)
/////////////////////	//////////////////////////
low — very high	low — very high

3. Relative level of organizational impact*

///	//////////////////////////
minor — major	minor — major

4. Staffing requirements for development and revision

////////////////////////////////	//////////////////////////
conventional staff — trained conventional staff — trained CAI staff	conventional staff — trained conventional staff — trained CAI staff

*Relative to other forms of CAI.

D. Courseware

4. Simulation

Simulations give students the opportunity to practice procedures or solve problems. A simulation can "stand in stead" of objects or systems and mimic changes in states based upon student actions. Simulations can also coach or tutor students along the way. Simulations are good instructional candidates when they diminish exposure to danger; time required to mastery; or reliance on more expensive, scarce or hazardous actual equipment. Level 1 below is a relatively good candidate for in-house development, whereas 2 is a good candidate for external development.

Level 1. Simulations at this level depict processes and/or equipment in a physical sense; i.e., a piece of equipment at various stages of operation or with various faults.

Level 2. Simulations at this level depict interacting processes and/or several pieces of equipment simultaneously; i.e., a nuclear power plant operation or a complete flight simulator.

A further discussion on simulation is provided in Section II.D.

D. Courseware

4. Simulation

	Level 1	Level 2
1. Overall complexity of development	/////////////////////////////	////////////////////////////////////
	simple — complex	simple — complex
2. Relative cost of development and revision*	(personnel costs)	(authoring aids costs)
	/////////////////////////////////	//////////////////////////////////
	low — very high	low — very high
3. Relative level of organizational impact*	/////////////////////////////	///////////////////////////////////////
	minor — major	minor — major
4. Staffing requirements for development and revision	//	generally external development
	conventional staff — trained conventional staff — trained CAI staff	conventional staff — trained conventional staff — trained CAI staff

*Relative to other forms of CAI.

5. Inquiry CAI

Inquiry CAI requires the user-students to initiate and control the sequence of the content presentation. This form of CAI can provide information, instruction, and practice segments but the objectives for their use and the sequence in which they are viewed are totally dependent on the user. More than just learner control, inquiry CAI requires the computer-based system to be "smart" and "user friendly," interfacing with the user through menus, keywords or natural language input.

This is not a good candidate for in-house development, and authoring aids for development of inquiry CAI which go beyond the use of sample menus are not commercially available. A further description of inquiry CAI is provided in Section II.D.

D. Courseware

5. Inquiry CAI

1. Overall complexity of development

//

simple — complex

2. Relative cost of development and revision*

//

low — very high

3. Relative level of organizational impact*

//

minor — major

4. Staffing requirements for development and revision

generally developed externally

conventional staff	trained conventional staff	trained CAI staff

*Relative to other forms of CAI.

D. Courseware

6. Intelligent (Generative) CAI

ICAI has taken some of the techniques of artificial intelligence and combined those techniques with the original objective of tutorial CAI in order to form true Socratic dialogues or coaching sequences. This is a form of CAI that is still in its infancy, but there are R&D efforts currently underway throughout DoD.

This form of CAI is not a good candidate for in-house development for two reasons. First, the type and level of development expertise required for ICAI will usually not be available in-house. There are research and development groups that are working in this area and if ICAI is going to be adopted, external contractors may be helpful. Second, development or authoring aids are not as yet commercially available. Within the next 5 to 7 years, ICAI generation systems may become available but until that time, external development of ICAI is recommended or applying some ICAI techniques to tutorial CAI development is suggested. A further explanation of ICAI is provided in Section II.D.

6. Intelligent (Generative) CAI

//

simple complex

2. Relative cost of development and revision*

//

low very high

3. Relative level of organizational impact*

///

minor major

4. Staffing requirements for development and revision

generally developed externally

conventional staff — trained conventional staff — trained CAI staff

*Relative to other forms of CAI.

IV. DECISION AIDS FOR CONSIDERING THE ADOPTION OF CAI

A. Use of This Section

In previous sections, this handbook provided factual information about CAI, innovation and change, CAI efforts in the Department of Defense, cost factors, and related considerations in the CAI adoption process. This section does not present any new information. Rather, it provides the decision aids needed to assess the value of CAI in a particular training situation. These decision aids consist of worksheets with point scores and a decision flow chart. In this decision process, it may be helpful to refer to specific information in Sections II and III.

It will be useful to study the Decision Flow Chart (Figure IV.1) and the list of Decision Aids (Table IV-1). It should be noted that decisions about hardware and software requirements are based on the instructional requirements. By determining the need-to-have and nice-to-have instructional features and functions, the software needed to support those functions can also be determined, and then the hardware that operates required software and meets organizational requirements can be selected. The result of choosing hardware before deciding on its function may be like buying a sports car and then realizing the real need was for a truck!

It will be necessary for the user of this handbook to bring to this decision process a personal analysis of the specific training organization and also the specific course objectives. One further note of explanation:

> **The decision to adopt CAI or to forego adoption of the medium at this time is not usually made on the basis of a strict binary decision process or media selection model. It cannot be explicitly prescriptive. Priorities, organizational structures, and other nonquantifiable considerations must be weighed. The purpose of this decision aiding method is to highlight for your consideration the many relevant factors and issues that must be considered. It may be an iterative process of accommodation of requirements based on available resources.**

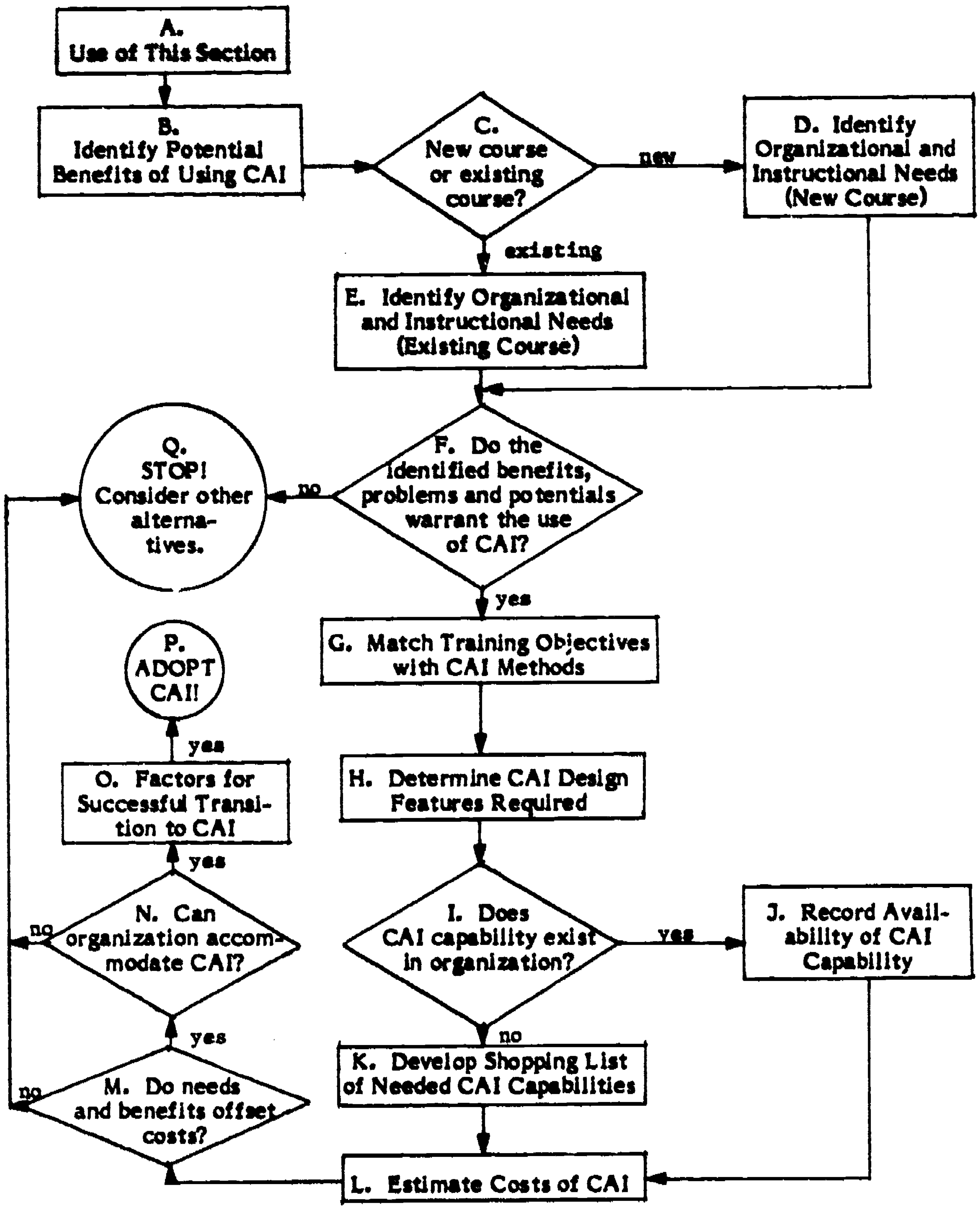


Figure IV.1. Decision flow chart.

Table IV-1

List of Decision Aid Worksheets

1. Benefits Assessment
2A. Organizational Needs (New Course)
2B. Instructional Needs (New Course)
3A. Organizational Needs (Existing Course)
3B. Instructional Needs (Existing Course)
4A. Training Objectives and CAI Methods
4B. CAI Methods Identification
5. CAI Design Features
6. Availability of CAI Design Features
7. Estimate Costs of CAI
8A. Assessment of Organizational Communication
8B. Assessment of Organizational Support and Resistance

B. Decision Aid 1: Identify Potential Benefits of Using CAI

If the course that is being considered for adoption of CAI is new, it provides a unique opportunity to give consideration to what is possible rather than responding only to problems arising from an existing set of constraints in curriculum structure, staffing, or facilities. The use of CAI in an existing course often must follow an evolutionary process in its implementation; thus, the adoption process tends to be incremental. However, for a new course, adoption of CAI can be considered on the basis of its being a major component of the instructional delivery process.

The following worksheet (Decision Aid 1) is structured to help in making a preliminary assessment of the need for CAI in a new or existing course as a function of both the training mission and the mission of the operational organization supported by the training group.

Decision Aid 1
Worksheet: Benefits Assessment

The following is a list of capabilities and/or requirements that influence the selection of CAI. Several of these items involve looking at training in a nontraditional manner. Evaluate each of the items on the basis of the following scale:

1	2	3	4	5
irrelevant, unimportant				essential requirement

	Rating
1. Provide pretraining in basic skills prerequisite to the required technical skills.	______
2. Provide for specialized technical skills to be taught in the context of specific weapon or support systems.	______
3. Reduce student time waiting for training, especially where the "Trained Personnel Requirement" is sporadic (i.e., not a constant and consistent input).	______
4. Accommodate highly variable aptitude levels in the trainee population.	______
5. Reduce the number of highly experienced personnel needed to staff the training program.	______
6. Compensate for the lack of or the expense of actual equipment or specialized equipment trainers.	______
7. Provide direct training support in the job rather than classroom environment.	______
8. Reduce the amount of time away from the job for training.	______
9. Accommodate rapid changes in technical information.	______
10. Provide familiarity with dangerous or infrequent operating conditions that cannot be simulated.	______
11. Provide for a great deal of hands-on experience that cannot be simulated.	______
12. Accommodate need for personnel to work predominantly as part of an integrated team.	______

13. Provide for fine motor skill behavior more than strong conceptual or rote skills. ______

14. Accommodate frequently changing work procedures. ______

15. Provide for a substantial degree of interpersonal skills which are needed for adequate job performance. ______

a. Add up the total value of your rating scores for items 1-9. ______

b. Add up the total value of your rating scores for items 10-15. ______

c. Subtract b from a. ______

If the value in c. is greater than 20, then CAI should be seriously considered as a significant component in the course design and development.

RECORD YOUR SCORE BUT DO NOT MAKE A PRELIMINARY DECISION AT THIS TIME.

PROCEED TO SECTION C

C. Is CAI Being Considered for a New or Existing Course?

If the course for which you are considering CAI is a new course,

PROCEED TO DECISION AID 2:

"D. Identify Organizational and Instructional Needs for a New Course"

2A. Organizational Needs
2B. Instructional Needs

If the course for which you are considering a CAI application is currently being delivered to students via some other method (i.e., lecture, programmed text, etc.),

PROCEED TO DECISION AID 3:

"E. Identify Organizational and Instructional Needs for an Existing Course"

3A. Organizational Needs
3B. Instructional Needs

D. Decision Aid 2: Identify Organizational and Instructional Needs for a New Course

The following worksheets (Decision Aid 2) require some assumptions about the new course which is being considered for CAI. The responses regarding both organizational and instructional needs are then analyzed.

Decision Aid 2
Worksheet 2A: Organizational Needs

Select the number that most closely fits the need described by each question.*

	3	2	1	Score Weighting	Score
1. Air Force requirements for people trained in this course.	immediate shortage	anticipated shortage	normal	if answer is 3 and QU 7 is scored as 1, subtract 2 points from total score	
2. Importance of reduced training time.	critical	important	currently adequate	add 3 extra points if scores in QUs 1 and 2 are both 3	
3. Anticipated technical personnel requirements (TPR) change in the next 2 years.	higher number	same number	lower number		
4. Anticipated availability of qualified and trained instructors.	critically lower number	slightly lower or same number	higher number	add 3 extra points if scores in QUs 3 and 4 are both 3	
5. Add three points for new course					
6. Course development and/ or revision time available.	adequate	short	critically short		
7. Availability of qualified course developers and support resources	more than adequate	adequate	inadequate	subtract 3 points from total if scores in QUs 6 and 7 are both 1	

*As you work through Decision Aids 2 and/or 3, you may wish to apply different weightings than those recommended here. This exercise will be equally valuable as long as you rationalize those weightings objectively based on your particular training situation.

Decision Aid 2 (cont.)
Worksheet 2A: Organizational Needs

	3	2	1	Score Weighting	Score
8. Anticipated problems in standardizing course content and procedures from class to class (e.g., safety, security certification, operational environment, etc.)	critical	important	N/A		
9. Will this course be conducted in physically separated operational environments visited by mobile instructional teams?	yes	partially	no		
10. A significant portion of the instruction is non-AFSC specific (e.g., career development, refresher, basic skills, study skills, etc.) <u>and</u> resources for the course are scarce.	yes to both	yes, but adequate resources	no to both		
				Total	

Generally courses generating scores between:

24 and 36 should be considered for CAI and may be excellent candidates based on organizational needs alone.

16 and 23 should be considered for CAI if instructional need score is greater than 15.

0 and 16 organizational needs alone do not justify adopting CAI. Requires an instructional need score greater than 25.

CONTINUE TO WORKSHEET 2B: INSTRUCTIONAL NEEDS

Decision Aid 2
Worksheet 2B: Instructional Needs

	3	2	1	Score Weighting	Score
1. Will your course have some objectives that are difficult to teach using current methods or any other media?	yes	very few	no		
2. Have you already decided to self-pace this course?	yes	cell-pace or self-pace selected sections	no		
3. If your answer to the previous question was yes, is student reading ability adequate for programmed text (P.T.)?	no	P.T. not used	yes	add 3 points if scores in QUs 2 and 3 are both 3	
4. Rate student motivation for the course.	low	medium	high		
5. Will students practice on potentially hazardous equipment or use potentially dangerous procedures?	yes	infrequently	no		
6. Is the course procedural and practice intensive? (Do not include need for manual practice and dexterity skills.)	yes	no			
7. Will actual equipment be used for practice? (Do not include need for manual practice and dexterity skills.)	yes	no			

Decision Aid 2 (cont.)
Worksheet 2B: Instructional Needs

	3	2	1	Score Weighting	Score
8. If your previous answer was yes, could the equipment or the process be simulated on non-actual equipment?	yes	no		add 2 points if scores in QUs 7 and 8 are both 3 and equipment is scarce or expensive	
9. Will your course require student teaming?	never	sometimes	often		
10. Will incoming students vary widely in background and previous training?	often	sometimes	never		
11. Are there secondary objectives in your course that are best supported with high instructor involvement (e.g., orientation to military life, orientation to the AFSC, etc.)?	none or yes but they are accommodated elsewhere	some	many		
				Total	

Generally courses generating scores between:

26 and 38 should be considered for CAI and may be good candidates on their instructional needs alone.

16 and 25 should be considered for CAI if the organizational need score is greater than 15.

0 to 16 instructional needs alone do not justify adopting CAI. Requires an organizational need score greater than 23.

PROCEED TO SECTION F.

E. Decision Aid 3: Identify Instructional and Organizational Needs for an Existing Course

Before proceeding through the evaluation of a specific course or training system, it might be useful to consider two general and basic questions:

Question 1. Does your course or training system accomplish its instructional objectives? Is it "successful" in meeting its training requirements?

> If you answered NO, and perceive that a training or organizational need is not currently being met, then it is reasonable to consider an alternative training response. To evaluate your instructional and organizational problems:
>
> **PROCEED TO WORKSHEETS 3A AND 3B**

> If you answered YES to question 1 and your training system or course is meeting its objectives:
>
> **PROCEED TO QUESTION 2**

Question 2. **If the training system or course <u>is</u> meeting its objectives, why is CAI being considered at this time?**

There are numerous noninstructional reasons for considering inclusion of CAI in a training system. This question is intended to bring into focus the specific training organization, the course, and perhaps, any personal motivation. Listed below are a few of the possible noninstructional reasons for considering CAI:

1. The conditions that contributed to the failure of previous attempts to make changes have been reviewed, addressed, and mitigated.
2. Personal interest in the technology.
3. Anticipated course resource and demand problems.
4. The introduction of a major revision to an existing course.

PROCEED TO WORKSHEETS 3A AND 3B

Decision Aid 3
Worksheet 3A: Organizational Needs

Select the number that most closely fits the need described by each question.*

	3	2	1	Score Weighting	Score
1. Air Force requirements for people trained in this course.	immediate shortage	anticipated shortage	normal	if answer is 3 and QU 7 is scored as 1, subtract 2 points from total score	
2. Importance of reduced training time.	critical	important	currently adequate	add 3 extra points if scores in QUs 1 and 2 are both 3	
3. Anticipated technical personnel requirements (TPR) change in the next 2 years.	higher number	same number	lower number		
4. Anticipated availability of qualified and trained instructors.	critically lower number	slightly lower or same number	higher number	add 3 extra points if scores in QUs 3 and 4 are both 3	
5. Is the course going through revision?	yes, major	yes, minor	no		
6. Course development and/or revision time available.	adequate	short	critically short		
7. Availability of qualified coursedevelopers and support resources	more than adequate	adequate	inadequate	subtract 3 points from total if scores in QUs 6 and 7 are both 1	

*As you work through Decision Aids 2 and/or 3, you may wish to apply different weightings than those recommended here. This exercise will be equally valuable as long as you rationalize those weightings objectively based on your particular training situation.

Decision Aid 3 (cont.)
Worksheet 3A: Organizational Needs

	3	2	1	Score Weighting	Score
8. Actual or anticipated problems in standardizing course content and procedures from class to class (e.g., safety, security, certification, operational environment, etc.).	critical	important	N/A		
9. Is this course being conducted in physically separated operational environments visited by mobile instructional teams?	yes	partially	no		
10. A significant portion of the instruction is non-AFSC specific (e.g., career development, refreshér, basic skills, study skills, etc.) and resources for the course are scarce.	yes to both	yes, but adequate resources	no to both		
				Total	

Generally courses generating scores between:

24 and 36 should be considered for CAI and may be excellent candidates based upon organizational needs alone.

16 and 23 should be considered for CAI if instructional need score is greater than 15.

0 and 16 organizational needs alone do not justify adopting CAI. Requires an instructional need score greater than 25.

CONTINUE TO WORKSHEET 3B

Decision Aid 3
Worksheet 3B: Instructional Needs

	3	2	1	Score Weighting	Score
1. Does your course have some objectives that are difficult to teach using current methods or any other media?	yes	very few	no		
2. Is your course currently self-paced?	yes	cell-pace or some sections are self-paced	no		
3. If your answer to the previous question was yes, is student reading ability adequate for programmed text?	no	P.T. not used	yes	add 3 points if scores in QUs 2 and 3 are both 3	
4. Rate student motivation for the course.	low	medium	high		
5. Do students practice on potentially hazardous equipment or use potentially dangerous procedures?	yes	infrequently	no		
6. Is the course procedural and practice intensive? (Do not include need for manual practice and dexterity skills.)	yes	no			
7. Is actual equipment used for practice? (Do not include need for manual practice and dexterity skills.)	yes	no			

Decision Aid 3 (cont.)
Worksheet 3B: Instructional Needs

	3	2	1	Score Weighting	Score
8. If your previous answer was yes, could the equipment or theprocess be simulated on non-actual equipment?	yes	no		add 2 points if scores in QUs 7 and 8 are both 3 and equipment is scarce or expensive	
9. Does your course require student teaming?	never	sometimes	often		
10. Do incoming students vary widely in background and previous training?	often	sometimes	never		
11. Are there secondary objectives in your course that are best supported with high instructor involvement (e.g., orientation to military life, orientation to the AFSC, etc.)?	none or yes but they are accommodated elsewhere	some	many		
				Total	

Generally courses generating scores between:

26 and 38 should be considered for CAI and may be good candidates on their instructional needs alone.

16 and 25 should be considered for CAI if the organizational need score is greater than 15.

O and 16 instructional needs alone do not justify adopting CAI. Requires an organizational need score greater than 23.

PROCEED TO SECTION F

F. Do the Identified Benefits, Problems and Potentials Warrant the Use of CAI?

The scores derived from worksheets in Decision Aids 1 and 2 (or 3) should provide a strong indication of whether there is a justification for further investigation and consideration of the potential adoption of CAI. If the score from Decision Aid 1 is very high (over 28), CAI should be considered regardless of the outcome from Decision Aid 2 or 3.

If scores on the worksheets provide justification based on need, or if you choose to proceed in the investigation of CAI,

PROCEED TO DECISION AID 4:

"G. Matching Instructional Tasks to CAI Methods"

If scores on the worksheets do not provide any justification for further consideration of CAI,

CONSIDER NON-CAI ALTERNATIVES

The bibliography in Section V of this handbook provides references to media selection models that may be of help in considering non-CAI alternative solutions to training problems.

G. Decision Aid 4: Matching Instructional Tasks to CAI Methods

The costs of CAI vary with the configuration chosen. Before the labor and cost implications of CAI can be estimated, it will be necessary to work through the following several worksheets in order to identify the CAI methods and supporting features that best match your requirements.

The following worksheet (Decision Aid 4) asks specific questions about the training targeted for potential CAI adoption. Each question describes an instructional attribute or learning outcome. The objective of this decision aid is to help in determining which CAI method matches a particular objective.

Decision Aid 4
Worksheet 4A: Matching Objectives with CAI Methods

Answer each of the following questions about your training objectives. Circle the appropriate responses.

1.	Do students require factual information in order to solve the instructional problem (e.g., does the student need to refer to manufacturer's specifications)?	Yes No
2.	Is the course a refresher or brush-up training in very specific areas?	Yes No
3.	While learning a new task, would students benefit from immediate feedback for each step in the solution to a question or problem?	Yes No
4.	Do students need to learn procedures or nomenclature "by heart" (recall)?	Yes No
5.	Would students benefit from direct instruction interspersed with relevant objective or constructed-answer questions?	Yes No
6.	Can students effectively master instructional material by reading, listening or watching the material passively?	Yes No
7.	Is it necessary for learners to be able to formulate, ask, and have a response to their own constructed questions?	Yes No
8.	Would it be advantageous to diminish reliance on expensive, scarce, or hazardous equipment used in the practice of procedures for instructional purposes?	Yes No
9.	Would a gaming environment increase student motivation in learning an otherwise dull or repetitive task?	Yes No
10.	Do students need intensive practice in recall or recognition of factual or procedural information?	Yes No
11.	Is it crucial to be able to diagnose a student's faulty reasoning/misunderstanding and use the diagnosis to guide and direct further instruction?	Yes No
12.	Do students need to be able to generalize what has been learned to problems that are dissimilar from the example problems already demonstrated?	Yes No

13. Would it be particularly advantageous to diminish the time required to gain relevant practice? Yes No

14. Should the students participate in defining the instructional objectives, the instructional content and the order of presentation? Yes No

15. Does the student need an opportunity to practice procedures or solve problems in realistic situations? Yes No

16. Is there a large body of organized information that students could profit from by browsing through at their own discretion? Yes No

17. Are there many ways to execute procedures or solve a given problem? Yes No

18. Is it possible to anticipate a small number of incorrect responses to typical instructional questions? Yes No

Decision Aid 4
Worksheet 4B: CAI Methods Identification*

Circle question numbers you answered "Yes" to on Worksheet 4A and note the suggested CAI method(s).

Informational	Drill-and-Practice	Tutorial	Gaming/Simulation	Inquiry	ICAI
1	4	3	8	2	7
6	10	5	9	14	11
16	12	18	13		
			15		
		17			

*See Section II.D. for a discussion of the characteristics of each of these CAI applications.

H. Decision Aid 5: Determine CAI Design Features Required for Targeted Instruction

At this point in the adoption decision process, there should be an early determination of the types of CAI required to meet the instructional objectives. The next task is to determine the primary features or capabilities needed to support both the instructional content and the requirements of the chosen CAI methods.

The cost of both hardware and specialized CAI software will be directly related to the type and number of CAI features needing support. Also, if a particular feature is not supported by an authoring language or system, a special program code in a higher order language to support that feature may need to be developed. This can impact both the cost and schedule for developing effective CAI materials which require the desired feature.

For simplicity, the features needed in a CAI system can be placed in three categories: presentation features, control features, and authoring features. Presentation features will be determined most by the characteristics of the content of the proposed instruction (i.e., text-oriented versus graphics-oriented). Control features will be determined most by the instructional method to be employed. Authoring features will be determined most by the experience level of the development staff and the quantity of courseware to be produced.

The following worksheet contains a list of both hardware and software features that either may be required or would be found desirable in a CAI system. The number and type of features chosen will directly impact the overall cost of the CAI system. This impact on cost can be either positive or negative. More features usually mean a greater cost for either the hardware or the software or both. However, some features, such as those for authoring, can reduce the support costs. When features are selected, the amount of CAI needed initially and the potential for expansion must be considered. Expansion to a larger system is always possible. Such an approach will avoid the need to purchase features that may not be necessary right now and will enable future needs to be met with more up-to-date technology. Often it is best to look at adopting CAI on an evolutionary or incremental basis; therefore, CAI features should be selected judiciously.

The issue for decision in this handbook is focused entirely on CAI; student and course record-keeping capabilities, characteristic of CMI systems, are not included. However, it may be desirable to look for a CAI system that has the ability to support some of these features.

Decision Aid 5
Worksheet: CAI Design Features

System Features	Need (check one) Yes	No	Comments
1. Presentation Features			
Text			
Alternate Character Fonts	____	____	The ASCII standard character set is the basic capability required. An alternate character set such as for scientific notation or for a language such as Russian would be needed for specialized instruction.
User-Defined Character Sets	____	____	This feature is often combined with the graphic capabilities of the system. It provides for establishing peculiar symbols or figures (e.g., electronic schematic symbols).
Highlighting - Color, Underlining, Blinking, or Reverse Image	____	____	These features are typically desired for emphasizing particular content. Color is more expensive and often is not really needed.
"Windows" and Selective Erase	____	____	These features are useful when it is desired to elaborate on a single concept. A statement of the concept or rule can be made at the top portion of the display while the bottom portion of the display proceeds incrementally through various examples.
Graphic Text	____	____	This feature is needed when it is desirable to manipulate the text in a variety of ways, such as creating dif-ferent sizes of text within a particular font.
Sizing and Rotation	____	____	These features are required when labeling of graphs or titling is needed.

System Features	Need (check one) Yes	No	Comments
Integrated Text and Graphics	____	____	This feature is especially important where the instruction requires a concept or object to be simultaneously explained and illustrated with different parts of the text corresponding to different portions of the illustration.
Graphics			
Character Graphics	____	____	This feature is sufficient for low-resolution images or where the graphic objects are basically static and can be composed of one or more defined character units. Illustrating a tool such as a hammer would be an example.
Vector Graphics	____	____	This feature is typically needed for high-resolution images, especially if diagonal and curved lines are frequently used.
Animation	____	____	This feature is needed for illustrating dynamic sequences.
Video	____	____	Access to a video input is important when real-world images or motion sequences are important to the instruction.
Graphic-Video Overlay	____	____	This feature allows one to emphasize or enhance a video image played from either a video tape or video disk with computer-generated graphics. This would, for example, permit a video image of a meter dial to be enhanced with the animated graphic image of the meter needle as a consequence of some learner input.

System Features	Need (check one) Yes	No	Comments
2. Control Features			
Learner Input Mode			
Keyboard	____	____	This is a minimum requirement.
Touch (screen panel or lightpen)	____	____	This feature is useful when it is believed that learners would have difficulty using the keyboard or when a majority of the instruction requires the learner to make visual identifications of parts of a graphic or video image.
Joystick, Mouse or Paddle	____	____	This feature is useful when it is desired that the learner control the movement of objects in th display.
Sequencing-Program Control			
Linear-Next Frame	____	____	This feature has the simplest control logic and is useful for the presentation of basic informational sequences or the sequential presentation of drill-and-practice items without remediation.
Author-Flagged Branch	____	____	This is the basic feature needed for conditional-type branching based on author-anticipated learner responses. It represents the minimum needed for drill-and-practice with remediation or tutorial instruction.
Data-Driven Branch	____	____	This capability is needed for more sophisticated tutorial strategies that take into account the learner's prior activities within the lesson. This capability is also essential to most forms of simulation. Branching is made on the basis of a decision algorithm.

System Features	Need (check one) Yes	No	Comments
Model-Based Branch	____	____	This is the basic capability necessary for intelligent CAI. The knowledge base underlying expertise is modeled as well as the ongoing performance of the learner. The sequence of instruction is unique to each learner.
Sequencing-Learner			
Menu-Driven Branch	____	____	This is the basic capability needed to allow a learner to control the next display of information to be presented. It is frequently used for informational sequences in CAI and "Learner-Control," tutorial-type CAI wherein, for example, the learner can optionally choose the number of examples to be seen.
Question-Based Branch	____	____	This feature allows a learner to seek information in a question format. It requires that the system have a model instructional knowledge base for a subject and at least an ability to properly interpret highly structured questions.
Answer Judging			
Key Word	____	____	This minimum capability allows the judgment of multiple-choice questions and constructed-response questions consisting of single words or short phrases. It depends on an exact match between the expected response entered by the author and the actual response of the learner.

System Features	Need (check one) Yes	No	Comments
Screen Location	____	____	This is a variation of the key word technique which allows the judgment of a location within the context of a display to be judged correct or incorrect. It is used with monkeyboard-type input devices and is usually important for simulation.
Synonyms	____	____	This is an additional capability to the key word match that will allow several forms of a learner's response to be judged correct. It evaluates only those words or phrases that are explicitly entered by the author.
Spelling	____	____	This is an addition to the key word technique which permits close spellings of the target word to be accepted as correct.
Multiword	____	____	This capability allows the judging of long phrases or complete sentences. This capability typically includes the ability to accept changes in word order and the possibility to ignore punctuation and/or capitalization. This is usually important for more sophisticated levels of tutorial CAI and represents a minimum capability for inquiry-based CAI.
Natural Language	____	____	This is a capability to accept and judge any learner input that represents normal usage of the learner's native language. All possible conditions for any particular response do not have to be explicitly entered by the author; rather, processing is based on a model of the knowledge base for a subject.

(Note. The following features pertain mainly to authoring languages or systems.)

System Features	Need (check one) Yes	No	Comments
3. Authoring Features			
Display			
Display At	____	____	This feature allows designation of a screen location at which the presentation of either text or graphic will start.
Specified Graphic Objects	____	____	These are commands or menu items which allow the author to easily create graphic objects such as lines, boxes (frames), circles, curves, etc.
Bit-Pad or Cursor-Controlled Graphic Input	____	____	This feature allows the creation of a graphic by the movement of a pen on an electronic pad or by the use of special keys to move a cursor around on the screen.
Object Manipulation	____	____	This provides a capability to treat a unit of text or a graphic as a single object and to move it around in "real time."
Editing Text	____	____	The provision of text editing allows at least the insertion and deletion of characters and/or words.
Editing Graphic	____	____	The provision of editing features allows the modification of a created graphic in "real time."
Copy	____	____	This feature provides the ability to designate and transfer a text or graphic object from one part of a lesson to another part or from a different lesson.

System Features	Need (check one) Yes	No	Comments
Library	____	____	This feature provides the ability to place frequently used graphic objects into a storage file from which they can be called into use within different lessons.
Abort	____	____	This provides the capability to cancel modifications to a lesson.
Control			
Branch Commands	____	____	These are specialized commands which permit the designation of the next lesson segment based on learner input (e.g., jump, next, go to).
Control Menus	____	____	This feature provides menus designating the possible control options for a particular segment of instruction. The author controls the sequence by setting flags or entering parameter values.
Learner Input			
Judge Commands	____	____	These are specialized commands which allow the author to designate correct and incorrect choices.
Response Menus	____	____	This feature provides menus listing possible judgment options such as ignore spelling, acceptable synonyms, etc.
Function Keys	____	____	The author can designate specific keys to represent possible control options that the learner can exercise on a uniform basis throughout the lesson (e.g., help).
Screen Location	____	____	Commands or menu options permit the author to designate screen locations as an acceptable response input by the learner.

I. Does CAI Capability Currently Exist in the Training Organization?

If a CAI capability currently does exist or a mechanism has been established whereby a capability is available to your organization, you will need to know if it is adequate for your organizational requirements and the CAI design feature requirements defined by you in Decision Aid 5.

PROCEED TO DECISION AID 6:

"J. Record Availability of CAI Features and Capabilities"

If a CAI capability does not exist or if a capability has not been made available to your training organization, then you will need to define your requirements so adequate capability can be justified and procured.

K. Use Decision Aid 5 as a "shopping list" for needed CAI capabilities.

THEN PROCEED TO DECISION AID 7:

3. Decision Aid 6: Record Availability of CAI Features and Capabilities

If a specific training organization has, or has access to, a CAI capability, it must be determined if the required CAI features specified on the Decision Aid 5 worksheet are supported.

Decision Aid 6 requires that all "yes" responses be transposed from Decision Aid 5 and then the availability of these features be assessed. The completion of this decision aid will also aid in subsequent discussions with vendors.

AFTER YOU COMPLETE DECISION AID 6,
PROCEED TO SECTION L, DECISION AID 7: ESTIMATE COSTS OF CAI.

(You may find that some of the issues raised in Sections N, O, and P relating to organizational accommodations and responses to change are less relevant in your situation than the situation in which CAI is not already available. However, we suggest that you work through these sections as well.)

Decision Aid 6
Worksheet: Availability of CAI Design Features

System Features	Need (from Decision Aid 4)	Available Yes	Available No
1. Presentation Features			
Text			
Alternate Character Fonts	______	____	____
User-Defined Character Sets	______	____	____
Highlighting - Color, Underlining, Blinking, or Reverse Image	______	____	____
"Windows" and Selective Erase	______	____	____
Graphic Text	______	____	____
Sizing and Rotation	______	____	____
Integrated Text and Graphics	______	____	____
Graphics			
Character Graphics	______	____	____
Vector Graphics	______	____	____
Animation	______	____	____
Video	______	____	____
Graphic-Video Overlay	______	____	____
2. Control Features			
Learner Input Mode			
Keyboard	______	____	____
Touch (screen panel or lightpen)	______	____	____
Joystick, Mouse, or Paddle	______	____	____

System Features	Need (from Decision Aid 4)	Available Yes	No
Sequencing-Program Control			
Linear-Next Frame	____	____	____
Author-Flagged Branch	____	____	____
Data-Driven Branch	____	____	____
Model-Based Branch	____	____	____
Sequencing-Learner			
Menu-Driven Branch	____	____	____
Question-Based Branch	____	____	____
Answer Judging			
Key Word	____	____	____
Screen Location	____	____	____
Synonyms	____	____	____
Spelling	____	____	____
Multiword	____	____	____
Natural Language	____	____	____
3. Authoring Features			
Display			
Display At	____	____	____
Specified Graphic Objects	____	____	____
Bit-Pad or Cursor-Controlled Graphic Input	____	____	____
Object Manipulation	____	____	____

System Features	Need (from Decision Aid 4)	Available Yes	Available No
Editing Text	______	____	____
Editing Graphic	______	____	____
Copy	______	____	____
Library	______	____	____
Abort	______	____	____
Control			
Branch Commands	______	____	____
Control Menus	______	____	____
Learner Input			
Judge Commands	______	____	____
Response Menus	______	____	____
Function Keys	______	____	____
Screen Location	______	____	____

L. Decision Aid 7: Estimate the Costs of CAI

To properly determine the costs of using CAI, a great number of individual factors need to be considered. This worksheet is not intended to provide a detailed cost model for CAI. Rather, each set of items on the worksheet is included only to ensure that all major cost areas have been evaluated prior to making an adoption decision.

In estimating the costs associated with employing CAI, most likely valid data will be available for only a few cost categories (e.g., hardware). Detailed cost figures for existing training operations are likely to be sparse or missing altogether. Therefore, the cost analysis should include careful documentation of all the assumptions made in arriving at useable estimates for each of the specified cost areas on the worksheet. Quite often it will be better simply to provide percentage figures (i.e., 20% less facilities) rather than try to calculate exact dollars, since such figures can vary based on different estimating procedures.

The material on the following pages can be used in two ways. If cost is an overriding issue, work through each step of the decision aid. If cost is only of general interest at this time because of the availability of hardware or other reasons, Decision Aid 7 should be used to review elements that contribute to costs. In any case, the results of completing the following worksheet (Decision Aid 7) will provide a broad perspective on the major costs involved in using CAI.

Decision Aid 7: Worksheet: Cost Estimation

To develop a "ballpark" estimate of the cost of implementing a CAI system, at least three major categories of cost should be considered: hardware and software, courseware production, and support.

The following sections of this worksheet are designed to guide you in estimating these categories. Whenever possible, the estimates entered on this worksheet should be derived from available records and documentation, as well as discussions with vendors and instructors. It is likely that some estimates will reflect your best guess. Remember, however, that the accuracy of your overall cost estimate will, in large part, depend on the accuracy and completeness of your individual estimates for each cost factor considered.

Section A. Estimation of Hardware and Software Costs

In order to estimate computer system-related cost, it is necessary to determine the capacity, configuration, and capability of the computer that will be required.

1. To consider the cost associated with system configuration and size required to accommodate the anticipated CAI training environment:

1a. Estimate the total amount of student contact time for CAI. First, estimate the number of CAI course hours. Second, estimate the total number of students who will go through the course during the period of time indicated in 1a.

______ hrs	X	______	=	______ hrs	(1)
# of course hours to be implemented in CAI		# of students who will take CAI		Total student-CAI contact time	

1b. Estimate the total amount of time CAI will be made available. First, provide the total period of CAI usage, in days. This period of usage can be an entire year for a course taught continuously or it can be a few weeks for courses taught periodically. Second, provide the amount of hours per day that CAI will be supported. As an example this figure might be 6 hours or 12 hours (more than one shift).

______ days	X	______ hrs/day	=	______ hrs	(2)
Period of time CAI is to be available		Hours of CAI usage per day		Total hours of availability	

1c. Estimate the number of student stations required.

______	÷	______	=	______	(3)
Enter (1)		Enter (2)		# of student stations required	

1d. If the number of student stations required (3) is less than 15, base your hardware costs on the use of stand-alone microcomputers (see Sections III.B.3.1 and III.B.4.1.3).

If the number of student stations required (3) is greater than 15 but less than 64, base your costs on the use of a supermicrocomputer or a minicomputer configured either as a central or modular system (see Sections III.B.1.1 and III.B.2.1).

If the number of student stations required (3) is greater than 64, base your costs on a centralized system configuration using a mainframe computer or a networked system of local processors (see Sections III.B.1.1 and III.B.4.1.2).

2. To consider the costs associated with the required storage capacity:

2a. First, estimate the text characters in existing printed instructional materials which will be converted to CAI. The following guidelines can be used for this estimation.

1 typed single-spaced page	3,600	characters
1 typed double-spaced page	1,800	characters

__________ X __________ = __________ (4)

# of text pages	# of characters per page	Total # text characters for conversion

2b. Second, estimate the number of text characters that will be contained in newly developed CAI displays. The following guidelines can be used for this estimation.

1 24-line x 80-character CRT screen	1,152	characters
1 24-line x 40-character CRT screen	576	characters

(Based on 60% of full screen capacity)

__________ X __________ = __________ (5)

# of displays	# of characters per display	Total # of new text characters

2c. Third, estimate the amount of storage for graphics content.

When graphics are combined with text, use the following guidelines:

If screen density is 192 x 256 pixels, use a storage factor of 250.

If screen density is 240 x 560 pixels, use a storage factor of 500.

__________ X __________ = __________ (6)

#of graphic and text displays	Storage factor	Storage for partial graphics

For full-screen graphic displays use the following guidelines:

If screen density is 192 x 256 pixels, use a storage factor of 800.

If screen density is 240 x 560 pixels, use a storage factor of 1,600.

________ X ________ = ________ (7)

(# of full graphic displays) X (Storage factor) = (Storage for partial graphics)

2d. Calculate total storage requirements for text and graphics

________ + ________ + ________ + ________ = ________ (8)

(Enter (4)) + (Enter (5)) + (Enter (6)) + (Enter (7)) = (Total bytes)

2e. Calculate the approximate external storage required in megabytes.

(________ x .000001) + (________ x .4) = ________ (9)

(Enter (8)) x (Conversion to megabytes) + (Enter (8)) x (Factor for control and student data storage) = (Total megabytes of storage required)

2f. If the required storage space from equation (9) is between 1 and 4 megabytes, memory storage costs can be based on the use of 5¼" or 8" flexible disks.

If the required storage space (9) is greater than 4 megabytes, base your memory storage cost estimate on the use of hard disk units. If a stand-alone system configuration is to be used, consider the cost of a shared data network (see Section III.B.4.4.3).

3. To consider the cost of acquiring the required authoring system(s), refer to Sections III.C.1, C.2, and C.3.

4. To consider the cost of communication hardware required, refer to Section III.B.4.4.

5. To consider the costs associated with other organizational issues, refer to Section III.B. Note that the above decision points are based on costs related to a single course or CAI application. The system configurations recommended are by no means absolute but rather, represent something which might be reasonably independent of other organizational concerns.

6. The selection of appropriate hardware and software should be based on (1) a review of the material indicated in steps 1d, 2f, 3, 4, and 5 above and (2) your own analysis from Section III.B.

7. After identifying the general type and capacity of the computer required, cost estimates should be obtained from appropriate vendors.

8. Record your estimate of the total cost for hardware and software.

$__________ (10)
Total hardware and software cost estimate

Section B. Estimation of Courseware Production Costs

The development of CAI courseware may include (1) the conversion of traditional lock-step course materials, (2) the creation of CAI displays for materials not previously presented in a traditional format, and (3) the development of complex CAI materials to support simulation, inquiry, or intelligent CAI. The following sections of this worksheet allow for the possibility that more than a single approach is likely in order to develop appropriate courseware. Further, the time involved in the development effort will vary significantly, depending on the software to be used.

1. Estimate the number of hours required to translate existing instructional materials into instructional, drill-and-practice, and tutorial CAI materials using the matrix of weighting factors shown in Table 7B1.

Table 7B1[a]

Weighting Factors: Instructional Materials to CAI Materials

	Type of Development Software		
Type of Instruction	HOL	Authoring Language	Authoring System
Informational	100	50	25
Drill-and-practice	200	100	50
Tutorial	300	150	75

[a]The values presented in Tables 7B1, 7B2 and 7B3 are based on the experience of the authors and the results of military CBI development projects (see Kearsley, Hillelsohn, & Seidel, 1982; Lewis, et al., 1980; and Orlansky & String, 1979).

1a. Estimate of time for converting informational segments to CAI.

______	X	______	=	______	(11)
# of hours of conventional informational instruction		Appropriate weight factor (Table 7B1)		# of development hours for informational CAI	

______	X	______	=	______	(12)
# of hours of conventional drill-and-practice		Appropriate weight factor (Table 7B1)		# of development hours for drill-and-practice CAI	

1c. Estimate of time for converting tutorial segments to CAI.

______	X	______	=	______	(13)
# of hours of conventional tutorial instruction		Appropriate weight factor (Table 7B1)		# of development hours for tutorial instruction	

1d. Estimate total hours for converting conventional materials to CAI materials.

______	+	______	+	______	=	______	(14)
Enter (11)		Enter (12)		Enter (13)		Total hours for converting existing materials	

2. Estimate the number of hours required to create CAI displays for new instruction. For various types of CAI and development software, select the appropriate weighting factors from Table 7B2.

Table 7B2

Weighting Factors: Instructional Materials to CAI Displays

	Type of Development Software		
Type of Instruction	HOL	Authoring Language	Authoring System
Informational	1	.5	.25
Drill-and-practice	2	1.0	.50
Tutorial	3	1.5	.75

2a. Estimate of time to create new informational CAI:

____________	X	____________	=	____________	(15)
# of informational displays		Appropriate weight factor (Table 7B2)		# of development hours for informational displays	

2b. Estimate of time to create new drill-and-practice CAI:

____________	X	____________	=	____________	(16)
# of drill-and-practice displays		Appropriate weight factor (Table 7B2)		# of development hours for drill-and-practice displays	

2c. Estimate of time to create new tutorial CAI:

____________	X	____________	=	____________	(17)
# of tutorial displays		Appropriate weight factor (Table 7B2)		# of development hours for tutorial displays	

2d. Estimate total hours for creation of new CAI displays:

________	+	________	+	________	=	____________	(18)
Enter (15)		Enter (16)		Enter (17)		Total hours for developing new CAI displays	

3. The amount of development time for simulation-based CAI instruction is related to the degree of fidelity and the inclusiveness of coverage of the simulation. Increases in fidelity will usually be accompanied by a greater use of the graphic feature of the CAI system and increased requirements for the programming of specialized control algorithms.

   Classify the type of simulation to be developed, based on the following categories. The categories provided are a further refinement of the levels of simulation described in Section III.D.4.

   - Equipment-Procedural: This is a simulation involving practice in the operation of a piece of equipment in accordance with specific procedural guidelines.

   - Equipment-Troubleshooting: This is a simulation involving the assessment of the operating condition of a piece of equipment followed by the ability to take a decision-based, manipulative action on the represented equipment. The options that are possible at any particular point in the simulation are typically constrained by the designed functionality of the piece of equipment.

   - Process-Decisions: This is a simulation involving the capability to make decisions in real-time parameters as a function changes. The decision made is context dependent, with a multiplicity of options being possible at each decision point. Examples of this type of simulation would typically involve medical or management simulations.

3a. Having determined the number of hours of each type of simulation instruction to be developed, use the weighting factors shown in Table 7B3 to estimate the total number of development hours required for CAI simulations.

Table 7B3

Weighting Factors: Instructional Materials to CAI Simulations

Type of CAI Instruction	Type of Development Software		
	HOL	Authoring Language	Authoring System
Simulation			
Category a.	250	125	60
Category b.	350	150	75
Category c.	425	200	100

______ X ______ = ______ (19)
# of hours Category A | Appropriate weight factor (Table 7B3) | # of development hours for Category A

______ X ______ = ______ (20)
# of hours Category B | Appropriate weight factor (Table 7B3) | # of development hours for Category B

______ X ______ = ______ (21)
# of hours Category C | Appropriate weight factor (Table 7B3) | # of development hours for Category C

______ + ______ + ______ = ______ (22)
Enter (19) | Enter (20) | Enter (21) | Total development hours for CAI simulations

3b. Estimate of time for other types of CAI materials:

Estimating the development time for inquiry- or ICAI-type instruction is difficult because of the lack of a substantial experience base in these two areas of CAI (see Sections II.D.5 and .6). The development factor for the inquiry method of CAI should be based on the relative comparison of its complexity to that of tutorial CAI. ICAI is still primarily a laboratory-based concept lacking extensive implementation. Any application of ICAI should be undertaken only with an understanding of its risks and realization that the development will be contributing to the growth of a promising area of CAI. The selection of weighting factors is left to the user.

_______________ + _______________ = _______________ (23)

# of hours for developing inquiry CAI	# of hours for developing ICAI materials	Total development hours for other CAI materials

4. Estimate of the total number of hours required for CAI courseware development:

_______ + _______ + _______ + _______ = _______________ (24)

Enter (14)	Enter (18)	Enter (22)	Enter (23)	Total # of CAI development hours

5. The actual cost of CAI development will be related primarily to the cost of the personnel involved. It is recommended that a team approach be used. The team should consist of at least three individuals: instructional designer, subject matter-expert (SME), and coder or programmer. The actual design of a lesson involving primarily the instructional designer and the subject-matter expert is a constant in terms of the time required (i.e., does not change significantly as a function of the software used unless a design system is employed). Thus, the front-end design involving the designers and the SME is a larger percentage of the overall development effort for an authoring system than for an HOL. Use percentage figures (shown in Table 7B4) to help distribute the development time among personnel.

Table 7B4

Development Time Distribution Table

Type of CAI Instruction	Type of Development Software		
	HOL	Authoring Language	Authoring System
Front-end Design (designer and SME)	.20	.40	.60
Production (coder/programmer)	.80	.60	.40

5a. Distribute development hours among team members:

__________ X __________ = __________ (25)

Enter (24) | Appropriate percentage of time for designer (Table 7B4) | # of hours for designer

__________ X __________ = __________ (26)

Enter (24) | Appropriate percentage of time for SME (Table 7B4) | # of hours for SME

__________ X __________ = __________ (27)

Enter (24) | Appropriate percentage of time for coder/programmer (Table 7B4) | # of hours for coder/programmer

5b. Estimate personnel costs for courseware development:

__________ X __________ = __________ (28)

Hourly rate for designer | Enter (25) | Cost of designer

__________ X __________ = __________ (29)

Hourly rate for SME | Enter (26) | Cost of SME

__________ X __________ = __________ (30)

Hourly rate for coder/programmer | Enter (27) | Cost of coder/programmer

__________ + __________ + __________ = __________ (31)

Enter (28) | Enter (29) | Enter (30) | Total cost of personnel for courseware development

Section C. Support Costs

Contrasted to costs that are peculiar to hardware and software and CAI courseware development, there are general support costs associated with any instructional system which can vary as a function of the instructional methods or technology used. Such indirect costs include facilities, support personnel (can include instructors), and maintenance.

1. Facility costs

If your system hardware requirements have established the need for a computer processor and its associated hardware which is NOT a stand-alone or desk top unit, determine if a separate room or facility must be established for its operation. Also, determine additional classroom or laboratory facilities required. Such an additional facility would be a special learning center that would not normally be present in an existing instructional system. For a new course, it would be the classroom space over and above that which would be allocated for a more traditional instructional system. Additionally, specialized support equipment needs to be considered (special furniture, electrical distribution, etc.).

General yearly facility costs include rent or general support costs such as heat, light, building maintenance, etc. DO NOT include unless this is an added cost (i.e., rooms or facilities additional to those already being used for the existing instructional system or which would not be needed for a non-CAI system). Calculate the yearly general facility costs.

Consider facility modification costs associated with special support systems that need to be added. Such support systems would include such things as air conditioning not already present or increased electrical requirements. Calculate the costs of modifying facilities for CAI.

Evaluate if the use of CAI can result in reduced facilities (e.g., because of a reduction in instructional time). This figure should also include any reduction in the trainers, audio-visual aids, and actual job equipment that is used for instruction and which would be eliminated through the use of CAI. Calculate facility cost reduction as a result of adopting CAI.

______	+	______	-	______	=	______	(32)
General facility costs		Facility modification costs		Facility cost reductions		Net facility cost	

2. Operational Support Personnel

This cost category includes the cost of personnel associated with the use of CAI during delivery of instruction (not the development of instruction).

For instructional objectives for which CAI has been developed, the CAI lesson is the primary delivery mechanism. Thus, personnel that perform instructional monitoring or administrative functions SOLELY as a consequence of CAI usage should be costed as required support personnel. If instructor personnel would normally be required under an alternate instructional system and would be performing similar instructional monitoring or administrative functions, then their cost should not be associated with CAI.

Consider special noninstructional personnel (computer operators, system programmers, etc.) necessary for the daily operation of the CAI system.

CAI, through its ability to provide direct instruction and to reduce instructional time, can either reduce the number of personnel necessary to operate the instructional system or modify the types of personnel needed (e.g., rather than all instructors, a combination of instructors and instructional aides might be used).

______	+	______	-	______		______	(33)
Instructor/ administrator personnel costs		Noninstructional support personnel costs		Support personnel reductions		Net support personnel costs	

3. System Maintenance

This category provides for costs associated with the maintenance of a CAI system. These maintenance costs are associated with activities that are required for the normal, daily operation of the system, as well as the periodic, long-term upkeep of the system. The latter type of maintenance includes items such as hardware repair and replacement and the revision of instructional materials. Also, consider the following:

Yearly, recurring communication costs such as telephone line rentals;

Yearly cost of supply items associated with the daily operation of the CAI system (such items might be computer paper, printer ribbons, floppy disks, etc.);

Yearly cost of the maintenance contract(s) for the main computer hardware and its peripherals;

Yearly cost of the maintenance contract(s) for the CAI software acquired.

Estimate what percentage of the CAI courseware will be revised yearly. Multiply this percentage by the CAI development figure in part B.4, equation (24), of this decision aid. Using this percentage of development time and the personnel ratios in Table 7B4, figure the personnel costs for revising the CAI courseware.

Because CAI courseware is self-contained within the system, it is possible that the maintenance cost for courseware (as compared to an existing system) can be reduced. Such a cost reduction might occur if such things as printing, graphics, and secretarial/clerical costs are avoided as a consequence of using CAI. Calculate possible maintenance cost reductions.

______	+	______	+	______	+
Communication costs		Supply costs		Maintenance contracts (hardware)	

________	+	________	-	________	=	________	(34)
Maintenance contracts (software)		Courseware revision		Maintenance reductions		Net system maintenance costs	

Total System Support Estimate

________	+	________	+	________	=	________	(35)
Enter (32)		Enter (33)		Enter (34)		Net system support estimate	

Section D. Total Cost Estimates

________	+	________	+	________	=	________	(36)
Hardware and software estimate (10)		Courseware development estimate (31)		System support estimate (35)		Total estimated CAI system costs	

M. Do Needs and Benefits Offset Costs?

Decision Aids 1, 2, and 3 identified potential benefits and the instructional and organizational factors that suggest either for or against the adoption of CAI.

Worksheet 7 identified resources needed to support the CAI methods indicated by Decision Aids 4, 5, and 6, and provided a structure for estimating the costs associated with procuring and maintaining those resources.

1. Do the promised benefits of CAI offset the costs?

2. Is it likely that the required funding will be available?

No decision aid or worksheet can quantify this process any further. However, by now the necessary information has been obtained (or the missing data have been identified) in order to make the adoption decision. A final worksheet (Decision Aid 8) focusing on the issue of change brings one additional factor to the decision.

**PROCEED TO DECISION AID 8:
ORGANIZATIONAL ACCOMMODATION TO CHANGE**

N. Decision Aid 8: Organizational Accommodation to Change

By this time the results of working with this handbook should have indicated either the need for further data and analysis or a growing conviction that CAI is (or is not) indicated. The question of change, however, rests on far more than technical considerations. The handbook has provided a variety of techniques for identifying and diagnosing critical factors and limitations of the training course or courses. Some conditions, such as uneven student flow or the increasing complexity of training content, indicate the need for some accommodation. However, the presence of problems and the identification of delivery-related causes do not necessarily indicate the wisdom of making immediate major system changes.

The simultaneous integration of a new technology (i.e., CAI) with changes to the training environment introduce new concerns and new requirements for users of the technology.

An instructional technology that changes the existing training environment from one that is familiar and predominantly personal to one that requires considerable logistical planning, learning of new terminology and instructional approaches, and changing staff roles will, not unexpectedly, disrupt the existing organizational structure. A convincing demonstration of CAI's ability to make a significant positive impact on the training process may be required, suggesting the need for a phased approach. As has been stated in this handbook, a technological innovation that is only an element superimposed on a training system which remains substantially unmodified may contribute very little in exchange for the dislocation and adaptation required. The decision to adopt the new technology requires a realistic assessment of the system changes involved in its introduction and the willingness to make those changes welcome to those whom they impact.

Change, then, is often a mixed blessing, involving both risk and expense. Change can have undesirable and unexpected consequences. Clearly, change is necessary if the current training approach is totally incapable of meeting training goals and requirements, but this is only infrequently the case.

The following worksheet (Decision Aid 8) is designed to assist in determining the feasibility and advisability of initiating the adoption of CAI at this time. Should the results indicate that the conditions for successful adoption are not in place, then the items on the worksheet provide an indication of the kinds of support that need to be developed.

PROCEED TO WORKSHEET 8A

Decision Aid 8

Worksheet 8A: Assessment of Organizational Communication to Support CAI

Rate your course or group of courses in terms of the following organizational questions:

Consider your current organizational structure, would it currently:	Yes	Probably	No
1. Support the ongoing communication* required for <u>instructional development</u> (among curriculum developers, ISDers, instructors, programmers, administrators, budget managers)?	____	____	____
2. Support the ongoing communication required for <u>instructional delivery</u> (among administrators, course supervisors, instructors, curriculum developers, students)?	____	____	____
3. Support the ongoing communication required for <u>maintenance of CAI</u> and hardware (among administrators, budget managers, instructors, curriculum developers)?	____	____	____

- If your answers to questions 1-3 are "No," the chances of CAI succeeding are low; communication and cooperation are vital in a successful CAI implementation
- If your answers to questions 1-3 are "Probably," you must consider what changes are necessary and if there is realistic expectation for change.
- If your answers to questions 1-3 are "Yes," the chances of CAI succeeding are enhanced.

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*In a large organization, are there formal communication channels in place for systematic information exchange? If the organization is very small (less than 20 people), do the persons holding titles identified in each of the questions have opportunities for frequent discussions and informal information exchange?

Decision Aid 8

Worksheet 8B: Assessment of Organizational Support and Resistance

Estimate probable support and resistance to the introduction of CAI by the following training-related personnel. It is not necessary to record these estimates, but you should make mental notes about levels of support and resistance.

1. Top level management*
2. Budget personnel
3. Course/curriculum developers
4. Course supervisors
5. Instructors
6. Students
7. Others (i.e., existing CAI development team, research staff, etc.)

Items 1-5 have different relative weights in different organizations. Consider your organization and its key personnel: If resistance is rated "high" for those personnel, the chances of a successful CAI implementation are low. Flexibility and creativity are key organizational attributes in self-paced and CAI-based instruction. Low resistance to innovation is a related attribute.

*Support at this level is crucial.

O. Factors for Successful Transition to CAI

The benefits of CAI have now been considered, as well as the instructional and organizational training needs relevant to CAI and the financial and human resources required to support CAI implementation. The handbook concludes by summarizing the factors usually required for successful transition to CAI.

This handbook is intended to help its users make reasonable decisions about the possible adoption of CAI. It is not an implementation handbook. However, after completing the decision process, the following conditions must be put into place before a successful transition to CAI can be anticipated:

1. A leader/advocate has been identified.

2. Realistic planning has taken place, with sufficient budget allocations and an appropriate incremental demonstration phase, as necessary.

3. Involvement of the persons who, at various levels, will be using the CAI system has been encouraged.

4. Changing roles of staff and instructor personnel have been carefully defined, with a sensitivity to individuals' needs for creativity and flexibility in exercising these roles.

5. Approaches and materials needed to train staff personnel in their new roles as well as in the capabilities and operation of the selected CAI system have been planned and prepared.

6. A sufficient number of terminals to support training requirements and student flow are available.

7. Attention has been given to human factors issues, including a concern for student and instructor comfort.

8. Requirements for system storage, inventory, and maintenance have been specified and appropriate resources allocated to meet these requirements.

9. Consideration has been given to noninstructional functions that could be handled by the CAI system, thereby ensuring maximum system usage.

Closely related to the preceding conditions that can facilitate the implementation of CAI in a particular training environment is the concern with user acceptance and, more generally, the concept of organizational change.

Implementing any innovation in an ongoing organizational environment is essentially an exercise in organizational change. Personnel in the organization are required to "unlearn" old and familiar practices and to learn new ones. This process can often evoke anxiety, insecurity, and resistance on the part of most individuals involved. For these reasons, a conscious and deliberate effort must be made to plan effectively for the change and to incorporate strategies for enhancing user acceptance during the change process.

A number of researchers concerned with organizational change and the effective implementation of new training systems agree that resistance will be less if system users have been allowed to participate in diagnosing the training problem and selecting the appropriate solution--that is, if they feel the project is their own. This implies that an effective implementation strategy is one that helps users have meaningful input into the design, development, and evaluation of the system. The training manager responsible for making the decision of whether or not to implement CAI will need to make a special effort to include the user group to the greatest extent possible in both the decision and implementation process. The retraining of staff personnel in their new roles and responsibilities with the system is essential, but not sufficient. The successful implementation of a new technology and the system required to support it is dependent, in large part, on both appropriate staff indoctrination and involvement. The decision to adopt CAI at this time should depend to some extent on an assessment of whether the environment for change exists and on the abilities and willingness of the training manager and supervisors to address the organizational issues of implementing change. If the decision is made to adopt CAI, the first few pages of Section II should be reviewed at this time as a reminder for maximizing the potentials and minimizing the limitations of this powerful instructional tool.

V. RESOURCES

A. Using Technical Assistance Effectively

If by this time, the commitment has been made to introduce CAI into a particular environment, but all of the caveats and warnings related to the training introduction of change in general and to the introduction of CAI in particular seem to be somewhat overwhelming, the possibility of outside technical assistance (TA) should be considered. This handbook should provide sufficient guidelines to permit a decision regarding the adoption of CAI technology. If there is some doubt, after reviewing the decision aids, then technical assistance consultants can be of help in reviewing the decision process and outcomes, in assisting with the process of change or in providing special courseware products once the decision is made to develop them.

There are many experienced and competent consultants and contractors available to provide high quality assistance. However, in spite of good intentions on the part of both the providers and recipients of technical assistance, there are numerous instances of disappointment with the results. Therefore, the following recommendations are made for working with outside services for general assistance in the decision or initiation processes and for specific product-related assistance.

1. General Assistance in the Decision or Initiation Process

Although naming a single point of contact (facilitator) will assist the TA provider with the logistics of a site visit, there are advantages to forming a committee. If one person interacts exclusively with a consultant, the consultant may get a one-sided view of the environment and also if the key person is transferred or leaves the site for other reasons, as is frequently the case, the information exchanged between the consultant and the staff person is lost to the group. Related to the need to preserve information is the following recommendation.

Get a written report from the consultant. Oral briefings are useful and provide the opportunity for questions and dialogue, but some lasting evidence of the information exchange that can be reread at one's leisure is essential. Frequently TA recipients have complained that they thought they understood what the consultant was recommending when on-site, but in retrospect, they could not accurately reconstruct the advice. A recommendation that "sounded great at the time" suddenly seemed ethereal or too vague to implement or had a logical flaw that may be the result of inaccurate memory. When paying for a consultant's assistance, it is generally worthwhile to invest the extra funds required for a detailed written report, with both recommendations and a discussion of the rationale on which they were based.

The consultant's services can be improved if a round of private individual conferences is set up with key people in the organization and if these associates are guaranteed anonymity so that individual perceptions, opinions, and attitudes can be freely expressed without concern about attribution. Following the individual conferences, arrange for a group meeting so that each of the issues uncovered can be openly explored with all parties. Good TA providers will be able to re-express individual concerns as their own issues and in such a way that individuals are not identified overtly or by inference as having raised them. Frequently the mere presence of a neutral party can generate a less protective and more open and flexible attitude toward specific issues that are causing problems, particularly problems related to the introduction of change.

2. Specific Product-Related Assistance such as Courseware

In general there are distinct advantages to developing courseware in-house. First, the in-house staff is thoroughly familiar with the objectives and philosophy of the branch, the course, and its development. Therefore, there are none of the expensive orientation costs normally associated with start-up. Second, the internal team, because of intimate involvement will have a stake in assisting in the transition from development to implementation to utilization. However, there are several reasons why a consultant or contractor might be engaged for lesson development or course evaluation; for example,

- The requirement for specialized knowledge that is not readily available in-house, and related to that, it may be less expensive to have the job performed outside than to build a courseware staff capability in-house.
- A tight time schedule for development exists that an already overworked staff may not be able to meet effectively.

When engaging a consultant-contractor for courseware, training evaluation, facility design, etc., as many in-house staff people as possible should be involved in the process in order to generate the advantages associated with internal development (e.g., broad-based knowledge and a stake in the outcomes) and to minimize the alienation and subsequent resistance often associated with "outside" development.

As an example, for lesson development the consultant should go through the same needs assessment steps the training manager would take; i.e., develop familiarity with trainee background, training objectives, field requirements and availability of on-the-job training, past evaluations, instructor qualifications, physical and human resources for delivery and maintenance of instruction and a thorough understanding of the training environments and other demands placed on students and instructors during the training process. It is generally not sufficient to develop courseware based on Instructional System Development (ISD), Specialty Training Standard (STS), and Plan of Instruction (POI) requirements alone and certainly not advisable during the "transition to CAI" process where training tradition and instructor needs must be taken into account along with subject-matter and learning strategy expertise.

B. Glossary

ACOUSTIC COUPLER MODEM	A special type of modem which allows a standard telephone headset to be attached to a terminal to allow the transmission of data.
Ada	A structured program language. The new standard DoD language designed for mission critical systems. Has its basis in PASCAL-like structure. (Not an acronym.)
ADCIS	Association for Development of Computer-Based Instructional Systems. (See Section V.E.)
AECT	Association for Educational Communications and Technology. (See Section V.E.)
AEDS	Association for Educational Data Systems. (See Section V.E.)
AERA	American Educational Research Association. (See Section V.E.)
AFHRL	Air Force Human Resources Laboratory.
AFSC	Air Force Specialty Code.
AI	Artificial intelligence is the study and application of what is known about human intelligent behavior to the development of machine (computer) systems that model intelligent behavior.
AIDES	Advanced Instructional Delivery and Evaluation System. (A DoD CBI effort.)
AIS	Advanced Instructional System.
APDS	Advanced Personnel Data System.
APT	Authoring Procedure for TICCIT.
ARI	Army Research Institute.
ATC	Air Training Command.
AUTHORING LANGUAGE	Programming language with codes specifically designed to handle major courseware needs such as response judging.

AUTHORING SYSTEM	Prepackaged courseware templates or menu-driven editors designed to help authors create courseware without elaborate programming.
BASIC	Beginner's All-Purpose Symbolic Instruction Code. A general-purpose, high-level language designed for teaching programming. Intended for interactive use, it is intended to be simple to learn. BASIC is widely used on a variety of computers, especially minicomputers and microcomputers.
BAUD RATE	An analog unit of measure for transmission rate. Baud is usually equated to the digital rate of transmission referred to as Bits Per Second (BPS). Information can be sent by the computer at speeds that typically range from 110 to 1,200 baud, which translates to 10-120 characters per second.
BIT	Smallest quantity of data. Bit, which is a contraction of binary digit, refers to a number represented by either a 0 or 1. All the memory locations in a computer are identified by a binary number address.
BLTMS	Base Level Training Management System. (A DoD CBI effort.)
BYTE	Group of bits usually operated on as a unit. Since a byte consisting of 8 bits is customarily required to define an alphanumeric character, the 8-bit byte has become a de facto standard, although others were used. Computer memory and mass storage are measured in terms of bytes. The symbols K and M are used, respectively, to designate thousands and millions of bytes.
CAI	Computer-Assisted Instruction. Instruction in which students interact with a computer; a variety of interactive instructional modes are used, including drill-and-practice, tutorial, dialog, simulations, and games.
CAIS	Computer-Assisted Instructional Simulation.
CAL	Computer-Assisted Learning.
CASIMS	Computer-Aided Instruction Study Management System. (A DoD CBI effort.)

CASS	Course Authoring Support System. (Part of the Advanced Instructional System.)
CAVI	Computer-Assisted Video Instruction. The application of computer technology with either video disk or video tape technology.
CBE	Computer-Based Education.
CBESS	Computer-Based Educational Software System. (A DoD CBI effort.)
CBI	Computer-Based Instruction.
CBT	Computer-Based Training. Term used to describe instruction delivered by using a computer; includes computer-assisted or computer-managed instruction.
CENTRAL MEMORY	Organized collection of storage elements in the central processing unit of a computer into which instructions and data consisting of binary digits can be deposited and from which information can be retrieved. Compare with mass storage and off-line storage.
CENTRAL PROCESSOR	A unit of a computer that includes the circuits controlling the interpretation and execution of instructions.
CDTS	Computer-Directed Training System. (A DoD CBI effort.)
CMI	Computer-Managed Instruction. Use of a computer to guide a student through an individualized instruction program. Learning activities may be satisfied independent of the computer. The computer performs many of the administrative tasks such as diagnosing student needs, prescribing learning activities, and evaluating student accomplishments.
COBOL	Common Business Oriented Language. A business data processing language.
COMMUNICATIONS PROTOCOL	In a data communication network, the code standard that governs the priority and sequencing of data transmission.

CONFIGURATION CONTROL/ MANAGEMENT	A systems management process used to ensure that modifications made in either hardware, software, or courseware are in accordance with system standards and are compatible with the operation of other system components.
COURSEWARE	Computer-based curriculum materials. Contrasted with "hardware," which is the electromechanical equipment, and "software," which is the program for making the equipment perform in certain ways.
CP/M	Control Program for Microcomputers. A widely used operating system for microcomputers. (CP/M is a trademark of Digital Research Inc.)
CRT	Cathode-Ray Tube (terminal). A device used as a computer terminal which contains a television-like screen for displaying data. Most CRT terminals also have a typewriter-like keyboard.
DARPA	Defense Advanced Research Projects Agency.
DATA BASE	Collection of information, organized for retrieval. Generally, it is implied that this information is available in computer-readable form for either on-line or off-line access. However, some data bases which have been generated by a computer exist only in hard-copy form. An example may be the individual personnel records formed into a personnel data base.
DATA FILE	A collection of related records treated as a unit.
DATA PACKETS	A collection of data bits transmitted as a single unit in a communications network.
DEDICATED/UNLOADED TELEPHONE LINES	Dedicated telephone line is a voice-grade line which has been "conditioned" to limit distortion and noise. An unconditioned line is one which provides only the normal bandwidth necessary for voice transmission. An unloaded line provides a higher bandwidth than the voice-grade, unconditioned line.

DIRECT CONNECT MODEM	A modem which can be directly connected to the RS232C input/output part of a terminal or computer.
DISK DRIVE	A device consisting of a spindle on which a disk pack can be mounted for electronically storing data.
DOWNLOAD	To transmit data from one computer to another or from the central processor to a peripheral device.
DOWNTIME	Period of time during which the central processor is inoperable.
DTIC	Defense Technical Information Center.
DUMB TERMINAL	A terminal that acts as an input/output device only.
EEMT	Electronic Equipment Maintenance Trainer. (A DoD CBI effort.)
EPC	External Power Contactor.
EXTERNAL MEMORY	Memory storage which is not part of the central processing unit of a computer.
EXTERNAL STORAGE	Peripheral device for storage (i.e., tape or disk).
FILE MANAGEMENT CAPABILITY	A software capability within the operating system of a computer which allows for the creation and manipulation of data files on an external storage medium.
FLAT PANEL	A display device using the excitation of a gas or a crystal matrix to produce an image rather than the scanning of a phosphorous coating by an electron beam. Referred to as flat panel display technology because the depth of the display device itself is usually no more than 1 or 2 inches.
FLOPPY DISK	An oxide-coated plastic disk 5¼ or 8 inches in diameter enclosed in a protective covering that can be used for magnetically storing data.

FORTRAN	FORmula TRANslating system. A computer program language developed in the 1950s, primarily used to express computer programs by arithmetic formulas.
GAMING	A technique in which the learner is presented situations involving choices and risks. Generally the choices are made to resemble real-life situations and the players are "rewarded" for various decisions.
HARD DISK (storage)	An external memory storage device using a stacked series of magnetically coated, rigid metal disks.
HARDWARE	Physical equipment, as opposed to the computer program or method of use; e.g., mechanical, magnetic, electrical, or electronic devices.
HOL	Higher Order Language. A computer language that permits an action actually requiring several steps inside the computer to be specified by a single command. An example is COBOL. Higher order languages permit the programmer to be more productive than do assembly languages or machine languages.
ICAI	Intelligent Computer-Assisted Instruction. Computer-based instructional dialogue based upon techniques in artificial intelligence.
INTELLIGENT TERMINAL	A terminal with the ability to process data using the electronic components within the terminal without the need to access the power of a large computer.
INTERNAL STORAGE	Addressable storage directly controlled by the central processing unit of a digital computer.
IQI	Instructional Quality Inventory. A curriculum evaluation and design tool. (See bibliography.)
ISD	Instructional System Development. This is a methodology for organizing the process of developing instruction. ISD is based on general systems theory.
ISS	Instructional Support System. (A DoD CBI effort.)

KILOBYTE	The standard unit of memory. One kilobyte comprises 1,024 bytes. (An 8K home computer stores 8,192 bytes of 65,536 bits.)
LANGUAGE	A format that allows a programmer to communicate more efficiently with a computer where commands will give requested actions. (BASIC is one such language.)
LCD	Liquid Crystal Display.
MAINFRAME	Large computer that is capable of processing large amounts of data at very fast speeds, with access to billions of characters of data.
MAIN MEMORY	That computer memory that is directly accessible. In a microcomputer main memory is referred to as random access memory (RAM) or read only memory (ROM).
MEGABYTE	One million bytes.
MEMORY CHIP	A chip on which data are stored as electrical charges.
MICROCOMPUTER	Smallest category of computers. Microcomputers tend to be miniaturized, are often dedicated to performing simple tasks, and do not usually have much flexibility. Wrist watches and hand-held calculators are examples of the limited end of the scale. Personal computers which cost $10,000 represent the upper cost limit of these devices.
MICROPROCESSOR	The electronic components of an entire central processor unit created on a very small single silicon chip.
MINICOMPUTER	Category of computer designed to offer a medium-sized computer at low cost.
MODEM	MOdulator-DEModulator. A device that modulates signals transmitted over communication facilities.
MOUSE	An input device containing a ball-like element. When moved about a flat surface, the motion and direction of movement are transformed into X-Y coordinates for the display cursor.

MULTIPLEXER	An electronic device that allows several terminals to share a single communication line.
MULTITASKING (COMPUTER) OPERATING SYSTEM	The control software of a computer's central processor which permits the processing of more than a single program.
NPRDC	Navy Personnel Research and Development Center.
NSPI	National Society for Performance and Instruction (Programmed Instruction). (See Section V.B.)
NTEC	Naval Training and Equipment Center.
NTIS	National Technical Information System
OPERATING SYSTEM	Software which controls the execution of computer programs and which may provide scheduling, debugging, input/output control, accounting, compilation, storage assignment, data management, and related services.
PASCAL	A programming language designed to make it easy to write programs using structured techniques.
PASS	Professional Authoring Support System. (A courseware authoring system marketed by Bell and Howell.)
PCD1-2	PLATO Course Development. (A courseware authoring system marketed by Control Data Corporation.)
PIXELS	A single point of illumination on a display device.
PLATO	Programmed Logic for Automated Teaching Operations.
POI	Plan of Instruction.
PROCESSING	A term referring to the internal operations of a computer processor.
PROCESSING TIME	The amount of time it takes a computer processor to operate on a specified ..umber of instructions (units of computer code).

PROCESSOR	The central hardware unit which performs the basic operations on bits of data.
RAM	Random Access Memory. A type of storage in which data can be written into and read from the storage element.
RF	Radio Frequency.
RGB	Red, Green, Blue--standing for the separate input of the signals corresponding to the primary color "guns" in a color cathode-ray tube.
RING NETWORK	A configuration of computers or peripherals are serially connected such that any unit can communicate directly with any other unit.
ROM	Read Only Memory. A type of memory in which data can be read and used but cannot be altered.
SALT	Society for Applied Learning Technology. (See Section V.E.)
SELECTIVE ERASE	Refers to the ability to erase part of a screen display without affecting other portions of the same screen display.
SID	Simulation Development. (Part of the Advanced Instructional System. Marketed by McDonnell Douglas.)
SIZING	The process of determining how much central and external memory storage is required for a computer system to support the processing tasks required.
SMART TERMINAL	A terminal that has the ability to process data and function as a computer in addition to being an input/output device for a mainframe computer.
SME	Subject-Matter Expert.
SOFTWARE	Category of computer components which is restricted to instructions to the equipment (hardware). Typically, software can be divided into operating systems, computer languages, and application programs.

STAND-ALONE COMPUTER	A self-contained computer system consisting of at least a central processor, central memory, display device, and input device. Usually used to refer to a single-user, microcomputer-based system.
STAR NETWORK	A configuration of computers and/or peripherals in which a single computer controls the communication and data flow to the other units.
STS	Specialty Training Standard.
TERMINAL DRIVER	A software program which governs the communication of a computer with a particular terminal or class of terminals.
TICCIT	Time-shared, Interactive, Computer-Controlled, Information Television. (CAI system marketed by Hazeltine.)
TIME-SHARE	To use a device for two or more simultaneous purposes.
TPR	Technical Personnel Requirements.
TPSS	Training and Performance Support System.
TRIM	Time Related Instructional Management (system). (A DoD CBI effort.)
UPWARD COMPATIBLE	Characteristic which allows programs written on a lower level of system configuration for a particular processor to operate without change on higher level configurations using the same processor.
VIDEO DISPLAY UNIT	A part of a computer similar to that of a television where information is placed on its screen.
WISE	WICAT's Interactive System for Education.
WORD	A character string or a bit string considered as an entity.

C. Bibliography with Selected Annotations

Alty, J. L. The impact of microtechnology--A case for reassessing the roles of computers in learning. Computers and Education, 1982, 6, 1-5.

Anastasio, E. J., & Alderman, D. L. Coordination and facilitation of computer-based instructional research: Final summary of reports. Princeton, NJ: Educational Testing Service, December 1976.

Lists and describes each of the reports resulting from the Educational Testing Service (ETS) project on advanced training technology sponsored by the Advanced Research Projects Agency (ARPA). ETS research involved investigating the problems of instruction, with special emphasis on technological applications.

Arthur D. Little, Inc. Factors relating to the implementation and diffusion of new technologies: A pilot study, Volume two of appendices containing case studies. Cambridge, MA: Author, July 1979.

Avner, R. A. Internal evaluation of the PLATO system. Paper presented at the Association for the Development of Computer-Based Instructional Systems (ADCIS), Annual Conference, Wilmington, Delaware, February 21, 1977.

Avner, R. A. Cost-effective applications of computer-based education. Educational Technology, 1978, 18, 24-25.

Avner, R. A. Longitudinal studies in computer-based authoring. In H. F. O'Neil, Jr. (Ed.), Issues in instructional system development. New York: Academic Press, 1979.

Avner, R. A., Moore, C., & Smith, S. Active external control: A basis for superiority of CBI. Journal of Computer-Based Instruction, 1980, 6(4), 115-118.

Reports the results of a study designed to provide evidence that CBI is superior to other, less costly alternatives because it allows for active, individualized control over student interaction.

Berkowitz, M., & O'Neill, H. F. An annotated bibliography for instructional systems development (ARI-TR-426). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences, August 1979. (NTIS No. AD-A081 183)

Lists instructional developme... resources relevant to the Interservice Procedures for Instructional Systems Development Model (ISD). The documents are classified according to the 19 block ISD model and summaries identify them as related to authoring aids, procedures, or techniques.

Bork, A. Learning with computers. Bedford, MA: Digital Equipment Corporation, 1981.

Focuses on the use of the computer as a learning device. The chapters of this book are based on papers written during 10 years of work at the Physics Computer Development Project and the Educational Technology Center at the University of California. Included are chapters on graphics, computer dialogs, issues of fitting applications into the classroom, producing computer-based learning materials, and future possibilities.

Braby, R., et al. Handbook of format models for designers of technical training materials. Orlando, FL: TAE G (Navy) TR-129, August 1982. (NTIS No. AD-A124 129)

Brown, J. S., & Bobrow, R. J. Applications of artificial intelligence techniques in maintenance training. In New concepts in maintenance trainers and performance aids (Tech. Rep. IH-255). Orlando, FL: Naval Training Equipment Center, October 1975.

Brown, J. S., Rubinstein, R., & Burton, R. Reactive learning environment for computer assisted electronics instruction (AFHRL-TR-76-68). Lowry AFB, CO: Air Force Human Resources Laboratory, Technical Training Division, October 1976. (NTIS No. AD-A035 302)

Describes the development of several new computer-based strategies for teaching troubleshooting principles to electronics technicians. The report documents an experiment in which those strategies are presented to students to determine their attitudes toward the techniques and whether the training resulted in improvement of their skills. Results show students responded favorably and their performance improved quantitatively and qualitatively.

Bunderson, C. V. Authoring systems versus authoring languages for instructional systems development: Implications for Department of Defense (ARI-TR-78-A10). Alexandria, VA: Army Research Institute for the Behavioral and Social Sciences, 1978. (NTIS No. AD-A071 082)

One of a series of reports on the authoring process and computer-based instruction and artificial intelligence. Notes the distinction between authoring systems and authoring languages. Includes a discussion of the critical goals for effective authoring. These goals are reduced costs and maintaining or increasing the quality of the materials. Primary constraints to reaching these goals are high turnover of authoring personnel and the need for military authoring systems to fit into the ISD model.

Caffarella, E. P., Cavert, C. E., Legum, S. E., Shtogren, J. A., & Wagner, W. W. Factors affecting instructor/student ratios for self-paced instruction. Educational Technology, 1980, 20(12), 5-9.

This article reports on research aimed at developing a model to assess the optimal use of instructional personnel for self-paced courses. Twenty-five self-paced courses at seven locations were investigated. Although specifically designed for the military, the article also describes the implications for nonmilitary education and training.

Carbonell, J. R. AI in CAI: An artificial intelligence approach to computer-aided instruction. IEEE Transactions on Man-Machine Systems, 1970, 11(4), 190-202.

Chambers, J. A., & Sprecher, J. W. Computer-assisted instruction: Current trends and critical issues. Communications of the Association for Computing Machinery, 1980, 23(6), 332-342.

Charters, W. W., & Pellegrin, R. J. Barriers to the innovation process: Four case studies of differentiated staffing. Educational Administration Quarterly, 1973, 9, 3-14.

Clayton, J. S. Inhibitors to the application of technology. Educational Communications Technology Journal, 1979, Summer, 157-172.

Cohen, S. A. Dilemmas in the use of learner responsive delivery systems. Paper presented at the American Educational Research Association Annual Meeting, Los Angeles, April 16, 1981.

Collins, A., & Grignetti, M. Intelligent CAI (BBN Rep. No. 3181). Cambridge, MA: Bolt, Beranek, & Newman, Inc., 1975.

Dallman, B. E. Graphic simulation in maintenance training--Training effectiveness at cost savings. Paper presented at the Association for the Development of Computer-Based Instructional Systems (ADCIS), Annual Conference, Vancouver, Canada, 1982.

A discussion of Air Force-sponsored research in use of simulation for maintenance training. Simulation is described as a cost-effective alternative if the simulation matches the fidelity level requirements of the instruction or task.

Dallman, B. E., DeLeo, P. J., Main, P. S., & Gillman, D. C. Evaluation of PLATO IV in vehicle maintenance training (AFHRL-TR-77-59). Lowry AFB, CO: Air Force Human Resources Laboratory, Technical Training Division, November 1977. (NTIS No. AD-A052 623)

Documents an Air Force service test of the PLATO IV Computer-Based Educational System at Chanute Technical Training Center, Chanute AFB, Illinois. Thirty-five computer-assisted instruction (CAI) lessons were prepared, covering approximately 20 hours of instruction. The evaluation addressed six major areas. In the first area, instructional effectiveness, the PLATO-based version was the most efficient of the four compared. A cost analysis demonstrated that the Chanute application of PLATO was not cost effective, but the potential exists for enhanced benefits. A study of instructional impact showed student and instructor attitudes to be, respectively, favorable and acceptable. The fourth area, instructional material development, found the team approach to be effective, but the lessons did not exploit the full potential of PLATO. The study of the remaining two areas, management and human factors considerations, revealed minor adjustments necessary to accommodate PLATO within the military technical training environment.

Dare, F. C., Hill, C. E., Hall, F. A., & Wofford, B. R. Final report: Evaluation of the PLATO IV system in a military training environment (Vol. 1). Aberdeen Proving Grounds, MD: Author, June 1975.

Dean, P. M. Why CBI? An examination of the case for computer-based instruction. Journal of Computer-Based Instruction, 1977, 4(1), 1-7.

In this keynote address at the conference of the Association for the Development of Computer-Based Instructional Systems (ADCIS), Dr. Dean discusses what is important about the use of computers in instruction.

Deignan, G. M., Seager, B. R., Kimball, M., & Horowitz, N. S. Computer-assisted, programmed text, and lecture modes of instruction in three medical training courses: Comparative evaluation (AFHRL-TR-79-76). Lowry AFB, CO: Air Force Human Resources Laboratory, Technical Training Division, June 1980. (NTIS No. AD-A085 609)

Evaluates the comparative effectiveness of instruction delivered by the three methods. An analysis of learners who differ in characteristics such as aptitude and motivation is included.

Dennis, J. R. Tutorial instruction on a computer (Illinois Series on Educational Application of computers No. 6e). Urbana, IL: Illinois University at Urbana-Champaign, Department of Secondary Education, 1979. (ERIC Document Reproduction Service No. ED 183 186)

Describes a tutorial lesson to give teachers a model for comparing and contrasting a variety of instances of such lessons and to assist them in developing a personal understanding of what constitutes a tutorial computer lesson. Three flow charts are provided as examples of tutorial-style episodes.

Dodge, B.J. Designing instruction for intrinsic motivation: A theory-based approach. Paper presented at the Association for Educational Communication and Technology, Annual Convention, New Orleans, 1979.

Dodge, B. J. Learner interest and instructional design: A conceptual model. Paper presented at the American Educational Research Association, Annual Meeting, Boston, April 1980.

Education Week. The educational revolution is not "in the chips": Educators must demand more than thoughtless pedagogy from computer software. Education Week, April 21, 1982.

Eisele, J. E. (Ed.). Special issue on microcomputers in education. Educational Technology, 1979, 19(10).

The first section of this special issue has four articles on the use of microcomputers in education. The second section features computer software needs and the third section is an information resource, including a glossary of terms, a list of manufacturers, and a list of people and centers working with micros in education.

Ellington, H., Addinall, E., & Percival, F. A handbook of game design. New York: Nichols Publishing Co., 1982.

Ellis, J. A., Wulfeck, W. H., & Fredericks, P. S. The instructional quality inventory (2 vols.) (NPRDC-SR-79-24). San Diego, CA: Navy Personnel Research and Development Center, August 1979.

Everett, J. A., & Kizier, J. W. What the training manager should know about computer-based instruction (CBI). Washington, DC: U.S. Department of Energy, The Standing Committee on Research of the Interagency Advisory Group's Committee on Development and Training, June 1979.

The report defines, describes, and discusses the advantages of and the resources needed to develop a CBI system.

Fanley, F. E. When to use CAI in training. Training/HRD, 1981, January, 82-83.

A brief explanation and list of five criteria for the effective use of CAI.

Fletcher, J. D. Modeling the learner in computer-assisted instruction. Journal of Computer-Based Instruction, 1975, 1(4), 118-126.

This article identifies and reviews four models so that CAI can be adapted to individual learners. These models are derived from four areas: quantitative models of memory, regression models of performance, automation models of performance, and artificial intelligence.

Fortner, M. B. Important criteria to consider for evaluating instructional simulations. Paper presented at the Association for the Development of Computer-Based Instructional Systems (ADCIS), Annual Conference, Western Washington University, Bellingham, Washington, 1980.

This paper lists the advantages and disadvantages of computer simulations, as well as the criteria necessary for evaluating instructional simulations.

Francis, L. Guidelines for establishing and managing a computer-based education site (Rep. No. I-148). Urbana, IL: University of Illinois, Computer-Based Education Research Laboratory, October 1977.

The three parts of this paper outline management guidelines: (1) questions to be asked by those establishing or managing a computer-based education site, (2) the selection and training of a staff for the site, and (3) a variety of other issues and recommendations.

Frantini, R. C. A buyer's guide to computer-based instructional systems. Performance and Instruction Journal, 1981, 20, 17-20.

An article that provides a framework for the selection of the best computer system to meet individual computer-based instruction needs. Shared multiterminals, dedicated multiterminals, and stand-alone computer-based training systems are discussed. A series of questions designed to help the reader choose the proper system concludes the review.

Freda, J. S. Army training technology transfer: A systems model (ARI-RR-1241). Alexandria, VA: Army Research Institute for the Behavioral and Social Sciences, July 1980. (ERIC Document Reproduction Service No. ED 201 828)

Presents a framework for the establishment of an Army training technology transfer program and suggestions to improve the acceptance and use of training research products. This systems model uses a linear approach to describe the four steps of transfer: (1) analysis of requirements, (2) research, development, test, and evaluation, (3) dissemination of findings, and (4) institutionalization. Within these steps other specific issues of needs assessments, funding, and the transition from innovation to policy are considered.

Freda, J. S., & Shields, J. L. An investigation of the adoption process in training technology transfer (ARI-TR-448). Alexandria, VA: Army Research Institute for the Behavioral and Social Sciences, June 1980. (NTIS No. AD-A109 200)

Examines the transfer of Army training technology from the researcher to the user. This study used the Training Extension Course (TEC). Two major findings were (1) acceptance of TEC depends initially on internal sources of information and later on external sources, (2) the best predictor of TEC use was prior familiarity with it.

Frederick, F. J. Guide to microcomputers. Washington, DC: Association for Educational Communications and Technology, 1980.

A comprehensive guide to microcomputers and their use in education, this book provides names and addresses of companies and manufacturers for different models and the special features that are discussed. Chapters of special interest include those on subroutines in BASIC for answer processing in CAI, accessories, and microcomputers in management and instructional support applications.

Gagne, R. M. Developments in learning psychology: Implications for instructional design; and effects of computer technology on instructional design and development. Educational Technology, 1982, 22(6), 11-15.

An interview with Robert Gagne in which he discusses what is happening in the field of learning psychology. Dr Gagne's comments and observations touch on the shift from behaviorist to cognitive learning psychology, the influence of this shift on instructional design, emerging technology, and the merging of expertise from the fields of instructional design and computers.

Gagne, R. M., Reiser, R. A., & Larsen, J. A learning-based model for media selection: Description (Research product 81-25a). Tallahassee, FL: Florida State University, Center for Educational Technology, March 1981.

Gagne, R. M., Wager, W., & Rojas, A. Planning and authoring computer-assisted instruction lessons. Educational Technology, 1981, 21(9), 17-26.

Proposes a system for planning and authoring lessons that might be used with the new generation of microcomputers and associated hardware. The system outlined includes defining CAI lessons (types of learning outcomes, planning steps of instruction), authoring CAI (drill-and-practice, simulations, and tutorials), and guidelines for CAI authors.

Hall, K. A. Computer-based education. The best of ERIC, June 1976 - August 1980. Syracuse, NY: ERIC Clearinghouse on Information Resources, 1980. (ERIC Document Reproduction Service No. ED 195 288)

A bibliography containing annotations of reports, reviews, conference proceedings, and journal articles on computer-based education. This compilation is divided into seven subject headings: historical references, new technologies, new audiences, applications by various content areas, developmental efforts, research, and conference proceedings.

Harris, W. P. An authoring system for on-the-job environments. In H. F. O'Neil, (Ed.), Issues in instructional systems development. New York: Academic Press, 1979.

Hartman, J., & Garnett, D. A. A structured approach to the development of cc uter assisted instruction. Paper presented at the Association for Ec tional Data Systems, Minneapolis, May 5-8, 1981.

Outlines a structured approach that involves assessment of course goals and learner characteristics, analysis of tasks, selection of an instructional strategy, authoring techniques, and course testing.

Heuston, D. H. The promise and inevitability of the videodisc in education. Orem, UT: WICAT, Inc., 1977.

Hickey, A. E. Computer-assisted instruction: A summary of research in selected areas. Princeton, NJ: Educational Testing Service, January 1975.

Summarizes research on the application of technology to operational training. Major topic areas and trends covered in this report include subject-matter structure and instructional strategies, simulation, artificial intelligence, trainee testing and system evaluation, and authoring.

Himwich, H. A. (Ed.). Critique and summary of the Chanute AFB CBE project (MTC Rep. No. 14). Urbana, IL: University of Illinois, Computer-Based Education Research Laboratory, September 1977.

Himwich, H. A. A comparison of the TICCIT and PLATO IV systems in a military setting. Urbana, IL: University of Illinois, Computer-Based Education Laboratory, October 1977. (ERIC Document Reproduction Service No. ED 152 238)

Hoffman, J. L., & Waters, K. Some effects of student personality on success with computer-assisted instruction. Educational Technology, 1982, 22(3), 20-21.

Holmes, G. Computer-assisted instruction: A discussion of some of the issues for would-be implementors. Educational Technology, 1982, 22(9), 7-13.

Highlights some important questions regarding the implementation of a CAI facility. The basic question—why implement at all—is followed by a discussion of CAI effectiveness and increasing student motivation. Other questions included are costs; choosing a system; attitudes of administrators, teachers, and students; role of CAI in the curriculum; and sources of courseware.

Horn, R. The guide to simulations and games for education and training (3rd ed.). Cranford, NJ: Didactic Systems, 1977.

House, E. R. The politics of educational innovation. Berkeley: McCutchan, 1974.

Hymes, J. R., Hughes, J. A., & Faust, G. W. Method and media selection (Tech. Rep. 3). Orem, UT: Courseware, Inc., 1975.

Jamison, D., Suppes, P., & Wells, S. The effectiveness of alternative instructional media: A survey. Review of Educational Research, 1974, 44, 1-61.

Overview of the research on the effectiveness of the following alternative instructional media: traditional classroom instruction, instructional radio, instructional television, programmed instruction, and computer-assisted instruction.

Kaplow, R. A description of basic author aids in an organized system for computer-assisted instruction (ARI-TR-78-A8). Alexandria, VA: Army Research Institute for the Behavioral and Social Sciences, 1978. (NTIS No. AD-A070 189)

Provides details on a number of author aids that can be implemented in any organized system for CAI. A major premise of this paper is that the only system which can maximize author assistance is one which is organized along those lines from its inception and Kaplow concludes that it is far less satisfactory to tack on author aids to an existing programming language.

Kearsley, G. P. Some "facts" about CAI: 1976 in depth. Alberta, Canada: Alberta University, Division of Educational Research Services, 1976. (ERIC Document Reproduction Service No. ED 152 288)

Presents information about the state-of-the-art in CAI in 1976. This information takes the form of quantitative data on the number and average completion time of CAI programs according to subject matter, author, language, instructional strategies, sources, and central processor. These data provide an overview of activity in CAI useful for educational planning and decision making.

Kearsley, G. P. Instructional design in CAI. Alberta, Canada: Alberta University, Division of Educational Research Services, 1977. (ERIC Document Reproduction Service No. ED 152 293)

A conceptual framework for instructional design is introduced which includes three major components: task analysis (involving objectives, skills, and subject-matter structure), learner analysis (concerned with aged, population, and group characteristics), and means analysis (involving instructional strategies, techniques of evaluation and feedback, and media). An instructional design cycle is discussed which illustrates how these three components fit into an overall educational context. This framework is then used to consider the application of instructional design to CAI activities.

Kearsley, G. P. Some conceptual issues in computer-assisted instruction. Journal of Computer-Based Instruction, 1977, 4(1), 8-16.

A critical analysis of the conceptual framework and design philosophies of CAI. Discovers that inadequate notions of individualized instruction theory, failure to assess CAI effectiveness, and other theoretical problems present greater problems to CAI success than economic and technical hurdles.

Kearsley, G.P., Hillelsohn, M., & Seidel, R. Microcomputer-based training in business and industry: Present status and future prospects. Journal of Educational Technology Systems, 1981-82, 10(2), 101-108.

This article presents the results of a survey of microcomputer-based training systems. Of those using computers, 71 percent were using microcomputers. The major areas of use for computers in training were technical skills, programming/computer concepts, management/sales, administrative/clerical, and management. The two major types of use were simulation and problem/presentation tests. The trends that were revealed by the survey included video disks, video text, video conferencing, embedded learning, and distributed education.

King, A. T. Impact of computer-based instruction on attitudes of students and instructors: A review (AFHRL-TR-75-4). Lowry AFB, CO: Air Force Human Resources Laboratory, Technical Training Division, May 1975. (NTIS No. AD-A014 797)

Examines the evidence on whether contact with computer-based instruction leads to feelings of "depersonalization" or "dehumanization." The approach is to document investigations of attitudes toward CBI held by students and instructors before, during, and after exposure to CBI. Includes an assessment of the relevant literature.

Knerr, B. W., & Nawrocki, L. H. The measurement of military attitudes toward computer-assisted instruction (ARI-RM-78-18). Alexandria, VA: Army Research Institute for the Behavioral and Social Sciences, 1978. (NTIS No. AD-A077 966)

Reviews the interest in student attitudes toward CAI and concludes that this interest, although long-standing, has not produced well-integrated or consistent results. This report notes the following reasons for this lack of integration and consistency: (1) student attitudes are typically incidental to research or evaluation plans, (2) there is little agreement on an operational definition of student attitudes, and (3) the measuring instruments are designed ad hoc.

...ik, J. A., Kulik, C. C., & Cohen, P. A. Effectiveness of computer-based college teaching: A meta-analysis of findings. Review of Educational Research, 1980, 50(4), 525-544.

Integrates the findings from 59 independent evaluations of computer-based college teaching. The meta-analysis showed that CBI made small but significant contributions to course achievement and small, but positive effects on the attitudes of the students.

Leiblum, M. D. Organizing for computer-assisted learning. Educational Technology, 1979, 19(9), 7-10.

This article discusses the components of deciding where to place computer-based training within an educational institution's structure and defines the staffing needs necessary.

Levin, H. M., & Woo, L. An evaluation of the costs of computer-assisted instruction (Rep. No. 80-B7). Stanford, CA: Stanford University, Institute for Research on Educational Finance and Governance, May 1980.

Lewis, W. E., Lovelace, D. E., Mahany, R. W., & Judd, W. A. Computer-assisted instruction in the context of the advanced instructional system: Materials development procedures and system evaluation (AFHRL-TR-79-74). Lowry AFB, CO: Air Force Human Resources Laboratory, Technical Training Division, March 1980. (NTIS No. AD-A082 996)

Reports on a project to design, develop, implement and evaluate an authoring system for cost-effective production of CAI materials. Describes an authoring procedures model and instruction on use of software tools.

Lintz, L. M., Pennell, R., & Yasutake, J. Y. Integrated system test of the Advanced Instructional System (AIS) (AFHRL-TR-79-40). Lowry AFB, CO: Air Force Human Resources Laboratory, Technical Training Division, December 1979. (NTIS No. AD-A081 854)

This study was designed to provide quantitative answers regarding the training time reductions resulting from certain computer-managed instruction (CMI) functions of the AIS. The reliabilities of the CMI functions and of the AIS support systems (media, computer hardware, and software) were also investigated.

Magidson, E. M. Student assessment of PLATO: What students like and dislike about CAI. Educational Technology, 1978, 18(8), 15-19.

Reports a survey of students who had been exposed to CAI for at least one semester, ranging from 7 to 30 hours. The author used 20 agree/disagree questions and two open ended categories. Students responded favorably to CAI using PLATO. The few problems mentioned included frustration with computer failures, insufficient computer lesson space, terminal breakdowns, and difficulty operating terminals.

Malone, T. W. What makes things fun to learn? A study of intrinsically motivating computer games (Cognitive and Instructional Sciences Series, Rep. No. CIS-7). Palo Alto, CA: Xerox, August 1980.

McCombs, B. L., Back, S. M., & West, A. S. Self-paced instruction: Factors critical to implementation in Air Force technical training--a preliminary inquiry (AFHRL-TP-84-23). Lowry AFB, CO: Air Force Human Resources Laboratory, Training Systems Division, August 1984.

McCombs, B. L., & Dobrovolny, J. L. Theoretical definition of instructor role in computer-managed instruction (NPRDC-TN-80-10). San Diego, CA: Navy Personnel Research and Development Center, March 1980.

Summarizes the literature in the areas of theoretical frameworks for defining ideal instructor roles and existing CMI system functions and definitions of those roles. Two primary instructor roles are identified and five major categories of instructor functions are identified as directly supporting student learning.

McGuire, C., Solomon, L., & Bashook, P. Construction and use of written simulations. New York: The Psychological Corporation, 1975.

McManus, J. C. Equipment comparability techniques used during early system design (AFHRL-TR-79-24). Wright-Patterson AFB, OH: Air Force Human Resources Laboratory, Advanced Systems Division, July 1979. (NTIS No. AD-A071 411)

Presents a systematic study of the state-of-the-art in comparing proposed equipment to existing operational equipment. The study involved a review of the literature, interviews of personnel who perform comparability analysis, and the examination of comparability studies used in the past.

Micheli, G. S., Morris, C. L., & Swope, W. M. Computer based instructional systems--1985-1995. Orlando, FL: Training Analysis and Evaluation Group, Chief of Naval Education and Training, 1980. (ERIC Document Reproduction Service No. ED 194 052)

Discusses developments in CBI and presents initiatives for the improvement of Navy instructional management in the 1985 to 1995 time frame. The major categories of current CBI systems are examined in the context of their problems and capabilities; future trends are presented; and an economic assessment of Navy needs is provided, including projected technological capabilities in hardware, software, and courseware to satisfy those needs.

Milner, S. D. Determining the feasibility of computer-based instruction. Washington, DC: Office of Personnel Management, Training Research and Evaluation Division, Workforce Effectiveness and Development Group, October 1979.

Milner, S., & Wildberger, A. M. How should computers be used in learning? Journal of Computer-Based Instruction, 1974, 1(1), 7-12.

Discusses three different classes of reasons for using computers in instruction. These three classes of reasons are reviewed in relation to corresponding kinds of computer applications, the level of computer capabilities used, and the educational benefits derived.

Misselt, A. L., & Call-Himwick, E. Analysis of Sheppard AFB computer-based education project (MTC Rep. No. 21). Urbana, IL: Computer-Based Education Research Laboratory, January 1978.

Misselt, A. L., Francis, L., Call-Himwick, E., & Avner, R. A. Implementation and operation of computer-based education. Urbana, IL: University of Illinois, Computer-Based Education Research Laboratory, August 1980. (NTIS No. AD-A101 715)

Provides an administrative overview of the findings from a 5-year longitudinal study of factors affecting implementation and operation of computer-based education in military settings. These findings are generalizable to academic and industrial training situations as well. An annotated list of the 24 detailed reports produced during the project is included.

Montgomery, A. D., & Judd, W. A. Computer-assisted instruction in the context of the advanced instructional system: Authoring support software (AFHRL-TR-79-12). Lowry AFB, CO: Air Force Human Resources Laboratory, Technical Training Division, December 1979. (NTIS No. AD-A081 071)

Details the design, development, and implementation of computer software to support the cost-effective production of CAI within the context of the Advanced Instructional System (AIS). Software components detailed are Authoring Editor, Presentation Program, Data Collection, and Data Print.

National Technical Information Service. Computer-aided instruction. September, 1979, December, 1981 (Citations from the NTIS Data Base). Springfield, VA: NTIS, January 1982. (NTIS No. PB82-803628)

Reports on the use of computers in education, and the computer systems necessary, are cited. Topics include motivation, technical training, learning factors, and human factors engineering. This updated bibliography contains 338 citations.

Navy Personnel Research and Development Center. Prospects for low-cost CBT: A forecast (SR-79-16). San Diego, CA: NPRDC, April 1979.

Office of Technology Assessment. A survey of computer technology (Working Paper No. 1). Washington, DC: Congress of the United States, September 1979.

O'Neil, H. F. Computer-based instruction: A state-of-the-art assessment. New York: Academic Press, 1981.

Provides an intellectual framework for recent and future CBI research. Chapter 1 is a general introduction to CBI and provides an overview of the rest of the book. An idealized computer-managed instructional system, described in Chapter 2, provides a conceptual framework for the field of CBI. CBI hardware and software are summarized in Chapter 3; courseware developments are the focus of Chapter 4. In Chapters 5 and 6, learning strategies and evaluation are reviewed. Chapter 7 focuses on the management aspects of CBI projects. The final chapter is a discussion of CBI in Europe and Japan.

Orlansky, J., & String, J. Cost-effectiveness of computer-based instruction in military training (IDA Paper-P-1375). Arlington, VA: Institute for Defense Analysis, Science and Technology Division, April 1979. (ERIC Document Reproduction Service No. ED 195 227)

Evaluates the cost effectiveness of conventional, individualized, computer-assisted, and computer-managed instruction. Concludes that students prefer CAI or CMI to conventional instruction, attitudes of instructors are unfavorable to CAI and CMI, individualized instruction (without computer support) saves student time, and little additional student time is saved when the same courses are given by CAI or CMI. Cost savings attributed to CAI and CMI are based on estimates of pay and allowances of students for time saved by these methods.

Orlansky, J., & String, J. Computer-based instruction for military training. Defense Management Journal, 1981, Second Quarter.

In the Department of Defense, the training budget is approximately $8.8 billion. This report emphasizes the need to train effectively while at the same time minimizing cost, by comparing individualized instruction, computer-assisted instruction, and computer-managed instruction.

Orlansky, J., & String, J. Cost-effectiveness of maintenance simulators for military training: Final report. (IDA Paper-P-1568). Arlington, VA: Institute for Defense Analysis, August 1981. (ERIC Document Reproduction Service No. ED 212 254)

Discusses the cost effectiveness of using maintenance simulators as opposed to actual equipment trainers. The study found simulators to be as effective as equipment in terms of student achievement. In 7 of 11 cases, the cost of a simulator was 60 percent less than for actual equipment. Report cautions, however, that effectiveness was based on school achievement not on-the-job performance and cost figures are based on acquisition not life-cycle costs.

Peters, R. D. Computer-based education and training functions: A summary. (NPRDC-TN-82-17). San Diego, CA: Navy Personnel Research and Development Center, May 1982. (NTIS No. AD A115 734)

Briefly describes the functions a computer can perform in educational and training settings and a taxonomy of these functions to facilitate an understanding of their interrelationships in a computer-based instructional system. It is intended for those involved with operational educational and training facilities in both armed services and civilian organizations.

Plato, G. J. The individual versus the computer: An examination of attitude problems and their impact on system development. Monterey, CA: Naval Post Graduate School, June 1981.

Discusses the problem of negative attitudes toward computer systems and ways to cope with emotional reactions. The role of managers, computer professionals, system users, and social institutions in promoting positive experiences and attitudes is examined.

Plocher, T. A., Miller, L. A., Gardner, J. A., & Cronin, J. E. The feasibility and applications of a computer based system for electronic test equipment and basic electronics training: Final report for period July 1976 - April 1977. Warminster, PA: Naval Air Development Center, 1977.

Roblyer, M. D. Instructional design vs. authoring of courseware: Some crucial differences. Paper presented at the Association for Educational Data Systems, Minneapolis, May 5-8, 1981.

Describes a courseware design model and systematic procedures for packages to facilitate efficient student learning. The differences between instructional design and authoring are pointed out.

Sandrin, J. V. Readiness for individualization of instruction: A school climate assessment procedure. Arlington, VA: Educational Resources Information Clearinghouse, 1982. (ERIC Document Reproduction Service No. ED 214 254)

To help assess a school's readiness for individualized instruction, the author devised the School Climate Assessment of Learning Environment (SCALE-I), a research instrument comprised of 30 belief statements about aspects of individualized instruction. Informants respond to the belief statements on an attitude scale.

The instrument was tested and the author concludes that it is a viable instrument for detecting a positive school climate for individualization of instruction.

Saylor, C. Computer-based learning--A primer (unpublished working paper). Golden, CO: Author, October 1981.

Outlines in detail computer-managed learning (administrative, support, and management) and computer-assisted learning (delivery).

Schulz, R. E. On-line authoring aids for developing test and instruction. In H. F. O'Neil, Jr. (Ed.), Procedures for instructional systems development. New York: Academic Press, 1979.

Schulz, R. E., Hibbits, N., Wagner, H., & Seidel, R. J. On-line authoring aids for instructional design (HumRRO-FR-ED-77-24). Alexandria, VA: Human Resources Research Organization, July 1979. (NTIS No. AD-A075 466)

Reports on a feasibility demonstration of on-line, query-based authoring aids for selected blocks of the Interservice Procedures for Instructional Systems Development (IPISD) model. The three levels of evaluation included evaluating existing IPISD materials, the newly developed authoring aids, and the instructional materials produced.

Seidel, R. J. It's 1980: Do you know where your computer is? Alexandria, VA: Human Resources Research Organization, 1980. (ERIC Document Reproduction Service No. ED 190 059)

Provides an evaluative framework to clarify the similarities and differences in five purposes for which a computer may be used to aid instruction. Each purpose implies its own method of evaluation and each has a different set of effectiveness measures that highlight its unique value. The first four involve adding new skills or knowledge to the instructional process, or what is called "value added" computer use; while the fifth deals directly with cost effectiveness. The five purposes are (1) computing opportunities--providing facilities for each school; (2) computer literacy--learning what "computer" means; (3) curriculum enhancement--attaining new objectives; (4) educational reform (e.g., high school education at home); and (5) cost effectiveness (e.g., comparison of two ways of learning English grammar). Measures of effectiveness for each of these purposes are discussed.

Seidel, R. J., Hunter, B., & Wagner, H. Tips for managing CAI projects. Educational Technology, 1978, 18(4), 33-37.

Seidel, R. J., & Wagner, H. Cost-effectiveness specification for computer-based training systems (3 vols.). Alexandria, VA: Human Resources Research Organization, September 1977. (NTIS No. AD-A081 812, Vol. 1; AD-A081 813, Vol. 2; AD-A081 814, Vol. 3)

This cost effectiveness specification is proposed to facilitate the purchase, monitoring, and evaluation of computer-based training systems. Provides a standardized structure for deriving and communicating training system costs in three volumes: Volume 1 is development; Volume 2 is procurement, and Volume 3 is operation and maintenance. Cost methodology quantifies total inputs required over system life cycle. Effectiveness measures include objectives achieved and time measures for criteria both within and at the end of the course.

Seidel, R. J., & Wagner, H. Management. In H. F. O'Neil, Jr. (Ed.), Computer-based instruction: A state-of-the-art assessment. New York: Academic Press, 1981.

Describes some of the lessons that managers of CBI systems have learned, with the hope that the mistakes made in the past will not be repeated. Begins with a general discussion of management in the context of different organizational structures and relates these structures to the complexities of projects involving instructional use of the computer. Examples of specific projects that illustrate how project purposes dictate staffing requirements and resources, types of management functions and the appropriate evaluation models to apply are presented.

Shavelson, R. J., & Winkler, J. D. Can implementation of computers be justified on cost-effectiveness grounds? (P-6781). Santa Monica, CA: RAND, June 1982.

Examines claims that technology can decrease educational costs and increase educational productivity. Finds these claims unwarranted based on a look at how most cost analyses are conducted.

Shirer, D. L. Computer systems for education: An evaluation. Tucson, AZ: University of Arizona, Computer-Based Instruction Laboratory, 1982.

Evaluates computers for education and categorizes into four broad groups: hobby, personal/professional, individual instruction stations, and centralized computer networks. Costs are compared as well as the advantages, features, and limitations of each group for educational use.

Shirer, D. L. Evaluation of computer-based instruction systems. Tucson, AZ: University of Arizona, Computer-Based Instruction Laboratory, 1982.

Spannaus, T. W. Speculations on computer-assisted design of instruction. Paper presented at the National Conference on Computer-Based Education, Minneapolis, October 1980.

Sprecher, J. W., & Chambers, J. A. Computer assisted instruction: Factors affecting courseware development. Journal of Computer-Based Instruction, 1980, 7(2), 47-57.

Identifies factors related to the development of materials for computer-assisted instruction. Two studies were conducted with computer center directors at public institutions of higher education and those faculty members nominated as "heavy" courseware developers. Opinions from both groups were obtained on similar factors relevant to courseware development.

Steinkerchner, R. E., Deignan, G. M., Waters, B. K., & DeLeo, P. J. Computer assisted instruction in Air Force medical training: Preliminary findings (AFHRL-TR-77-17). Lowry AFB, CO: Air Force Human Resources Laboratory, Technical Training Division, May 1977. (NTIS No. AD-A043 650)

Documents the procedures and findings from a study of the application of interactive terminals in medical training in the Air Force. This report of the first part of the study includes implementation conditions, student reactions, lessons learned, and cost data analyzed by health care scientists.

Suppes, P. Current trends in computer-assisted instruction. In M. C. Yovits, (Ed.), Advances in computers (Vol. 18). New York: Academic Press, 1979.

Tatsuoka, K. K., & Misselt, A. L. (Eds.). Attitude and performance of mili[illegible] students and instructor attitude in computer-based technical training (M[illegible]C Report No. 23). Urbana, IL: University of Illinois, Computer-Based Education Research Laboratory, January 1978. (ERIC Document Reproduction Service No. ED 201 320)

Assesses the effectiveness of the PLATO IV system in a military training environment. Focuses on student and instructor attitudes in four special purpose vehicle repairman courses and the relationship of these attitudes to achievement. Findings showed that a positive perception of effectiveness was associated with better achievement, but frustration and stress of learning led to less favorable results.

Taylor, S. S. CREATE: A computer-based authoring curriculum. In H. F. O'Neil, Jr. (Ed.), Issues in instructional system development. New York: Academic Press, 1979.

U.S. Air Force Manual, 50-2. Randolph AFB, TX: Air Training Command, 1979.

U. S. Congress. Hearings before the subcommittee on domestic and international scientific planning, analysis, and cooperation. House Committee on Science and Technology. 95th Congress, First Session, House Report No. 47. Washington, DC: U. S. Government Printing Office, 1978.

Van Matre, N. Computer-based instruction of the future: An electronic marketplace. Paper presented at the Symposium on Learning Technology for the 80s, Society for Applied Learning Technology, Warrenton, VA, 1981.

Examines the reasons why computer-based training as developed and conceived in the 1970s has not experienced the expected implementation in the 1980s. The implications for students and program managers and the future of computer-based training is discussed.

Vinsonhaler, J. F., & Bass, R. K. Ten major studies of the evaluation of CAI drill and practice (ISL Rep. No. 21). East Lansing, MI: Michigan State University, Information Systems Laboratory, August 1971.

Watson, P. A. The costs and economics of learning systems. Educational Technology Systems, 1977, 6.

Zinn, K. L., & Bork, A. Aspects of effective authoring systems and assistance: Recommendations for research and development (ARI-TR-78-A9). Columbus, OH: Army Research Institute, September 1978. (NTIS No. AD-A071 114)

One of a series of papers on the authoring process and CBI, this paper provides a brief historical look at computer-based authoring systems, gives details of the contributions the computer has made in developing teaching materials, and outlines the important aspects of the authoring process.

D. Screen Print Examples of CAI and Selected CAI Systems

In the following pages, actual screen prints of five different types of CAI have been included to illustrate what has been described in the other sections of this handbook. Intelligent CAI (ICAI) is not included in this collection of prints because it would of necessity be illustrated with static prints and the potential of this powerful tool would not be adequately demonstrated. Please refer to the bibliography for ICAI materials.

The use of static paper versions of dynamic, interactive instruction makes it very difficult to fully portray the strengths of the medium, such as nonlinear sequencing, user control through the use of "HELP" sequences, animation, and the ability of a program to track an individual's progress and tailor the instructional sequence to the strengths or weaknesses previously displayed by the individual. These examples should, however, provide some insight about the different uses of various CAI modes.

Two CAI development and user organizations have generously agreed to allow their screen-printed CAI instructional sequences to be included in this handbook. (Appreciation for written permission is extended to McDonnell Douglas Astronautics Company and the United Airlines Flight Training Center).

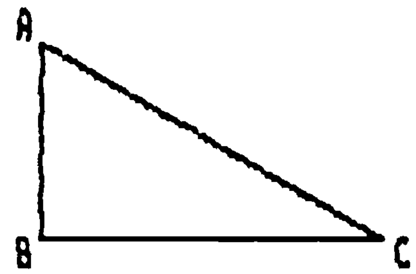
To aid in an adequate representation of the instruction, each screen print is annotated. These annotations appear on the page opposite the screen print.

Informational

The next two displays give a very simple example of how informational CAI can be used during a tutorial, drill-and-practice, or simulation sequence.

This display asks the student to answer a question for which the student is not expected to have all necessary information in memory. Specifically, the student must convert from inches to centimeters but is provided with the option to get that information on-line.

Given the following triangle:



$\overline{AB}$ = 3 inches

$\overline{BC}$ = 4 inches

What is the length of $\overline{AC}$ in centimeters?

>

Press key "PF1" for conversion factor chart

This display is the Informational CAI itself. It is an adjunct to instruction. Another example might have been the instructional screen as a form to fill out and the informational screen as the relationship governing the form. The information screen would be used, optionally, as reference.

Conversion Factor Chart

The standard unit of linear measurement in the metric system is the meter.

1 meter = 100 centimeters

1 meter = 39.37 inches

1 meter = 3.281 feet

Press RETURN to continue

Drill-and-Practice

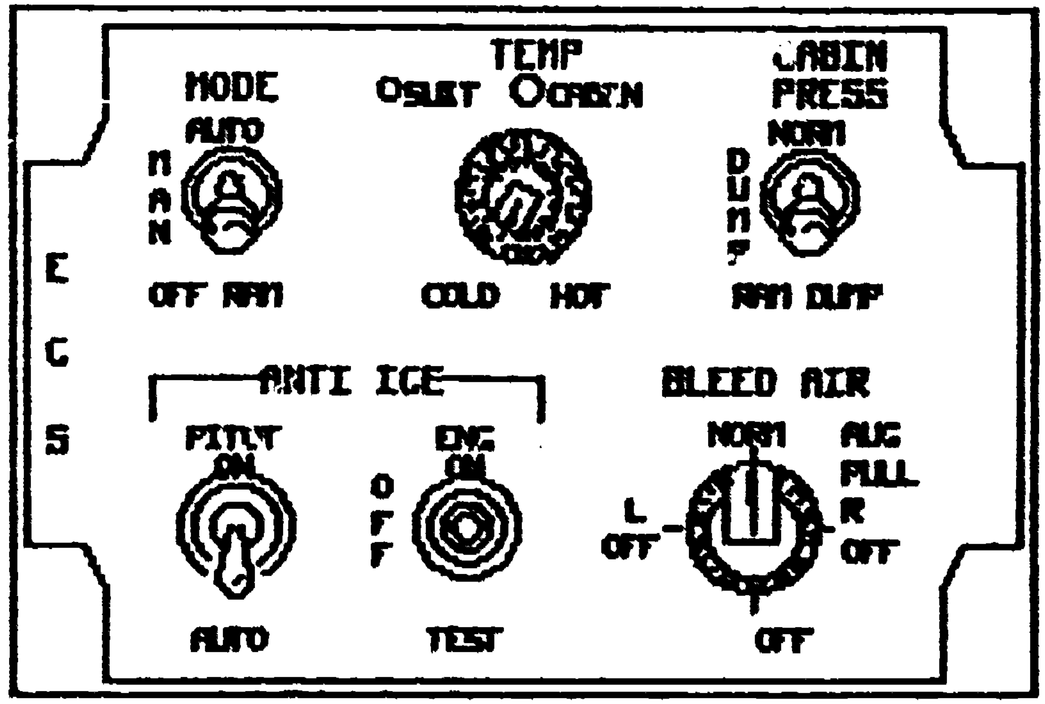
Students for this brief instructional segment have been given instruction before seeing this screen about the Control Panel referred to on the screen.

This screen focuses attention on one section of the panel while, at the same time, providing the context of the entire panel.

After some explanation of the Bleed Air Control Switch, the student is given the opportunity to practice bleed air control as shown in the following illustrations.

Press BACK to review

The Bleed Air Control Switch is located in the lower right hand corner of the ECS Control Panel.



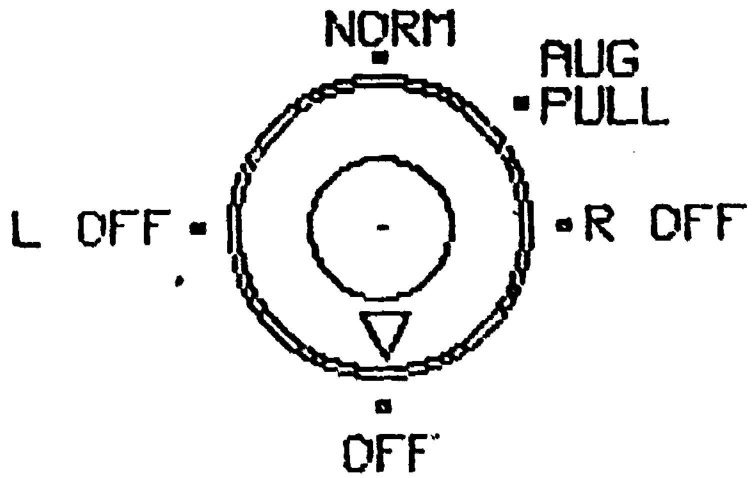
Press NEXT to go on; C to comment on material.

By permission of McDonnell Douglas Astronautics Company.

This screen depicts the effect caused by changes in the Air Bleed Control Switch.

Note that the switch is in the OFF position; the valves reflect that position.

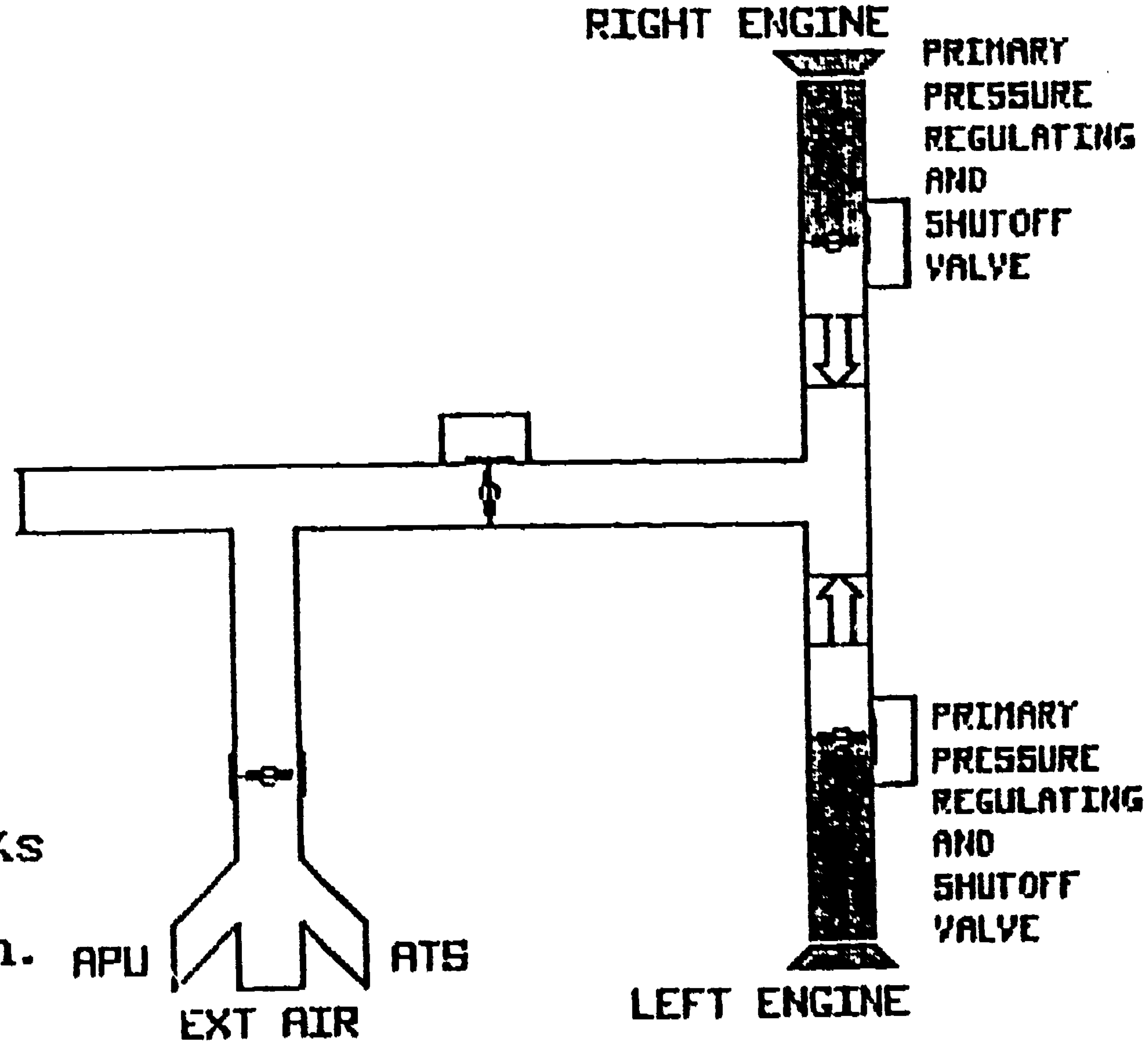
In the original, color is used effectively to highlight the changes in the system when the switch is altered. For purposes of economy in printing this handbook, the use of color is represented by shading.



Continue to touch the other switch positions, noting the effect to the Primary Regulating Valves.

201

Remember that AUGMENTATION PULL works only from the NORMAL position on the Switch.

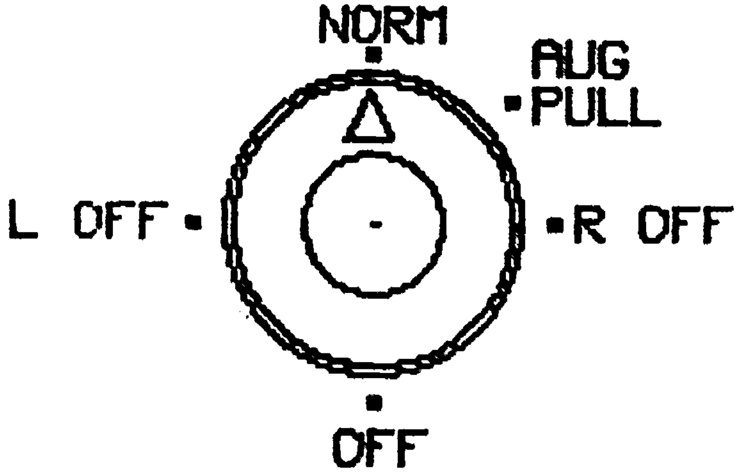


By permission of McDonnell Douglas Astronautics Company.

SELECT_

Note the change in valve positions as the student changes the position of the switch either by touching the screen at the new position or by using a light-pen to touch the screen. Shading depicts the extent of the changes to the system a change in the switch makes.

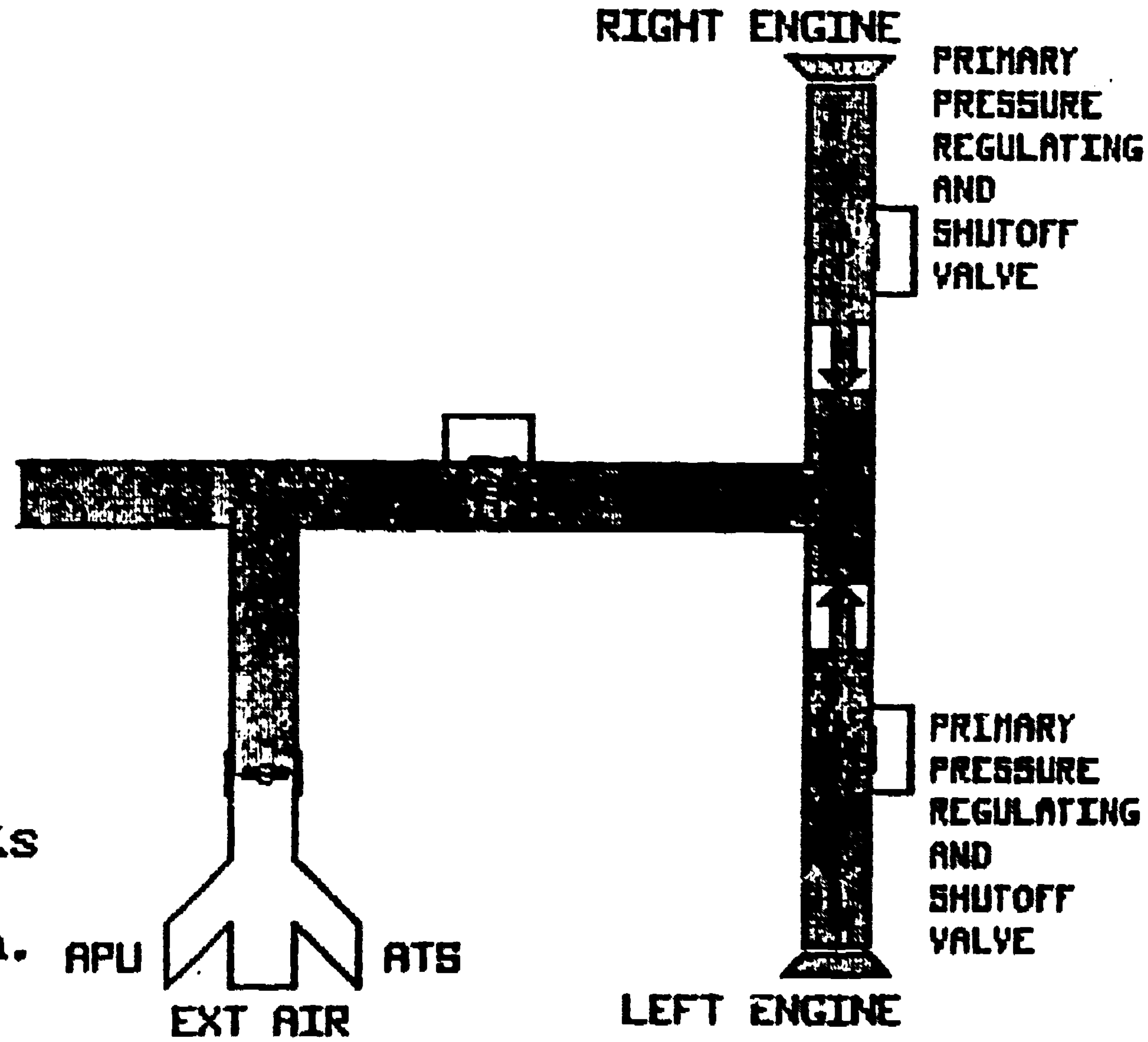
After the student practices changing the switch to see the effects (either for a minimum amount of time or until all switch settings have been tried), then the program offers an option to practice more or move on in the program, at the student's discretion.



Continue to touch the other switch positions, noting the effect to the Primary Regulating Valves.

203

Remember that AUGMENTATION PULL works only from the NORMAL position on the Switch.



SELECT _

Tutorial

The short segment on the following few pages provides users of this handbook with a glimpse at a short tutorial. Naturally, this small segment is embedded in the larger context of fuel systems of the F-18 aircraft. This short tutorial concludes with an embedded question. The choice of what next to present to the student is based upon the answer given. In this segment both color and animation were used to depict the flow of fuel. The color names have been added to show the purpose of the animation.

Press BACK to review

The following presentation
will deal with motive flow principles
used for transfering fuel
inside the CF-18 aircraft.

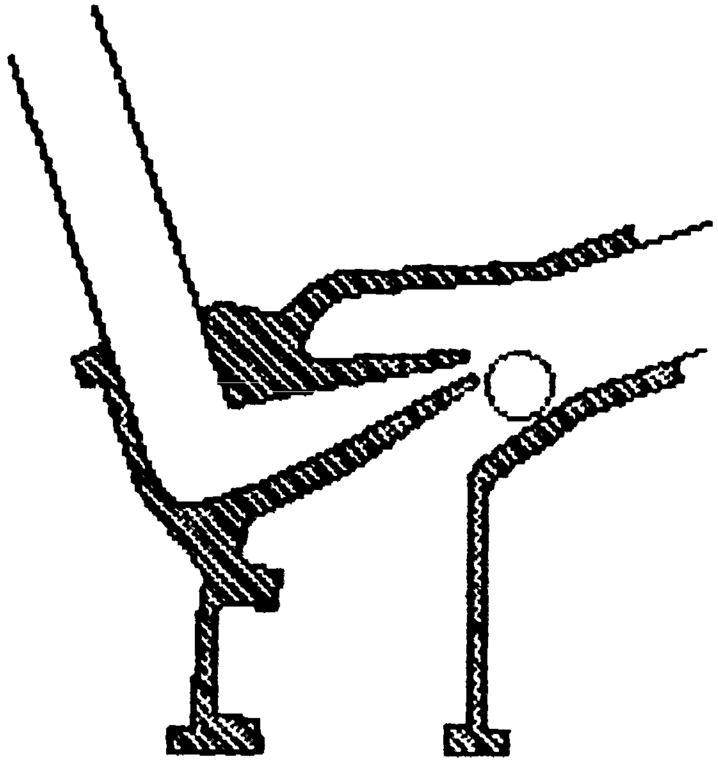
Some of the terms used may be new
or in need of clarification.

205

An explanation of terms
will be available to you
by pressing HELP.

Press NEXT to go on; C to comment on material.

This screen offers an explanation of the effect of pressure on fuel flow. When viewed on a screen, the circle moves. The movement not only shows the actual course the fuel takes but the velocity change is also depicted. Note the "HELP available" message at the top of the screen. Pressing HELP in this sequence, as noted on the previous screen, will lead to explanations of technical terms. Students also have the option of reviewing previous material by pressing BACK.



First, pressurized fuel flows through the venturi of an ejector.

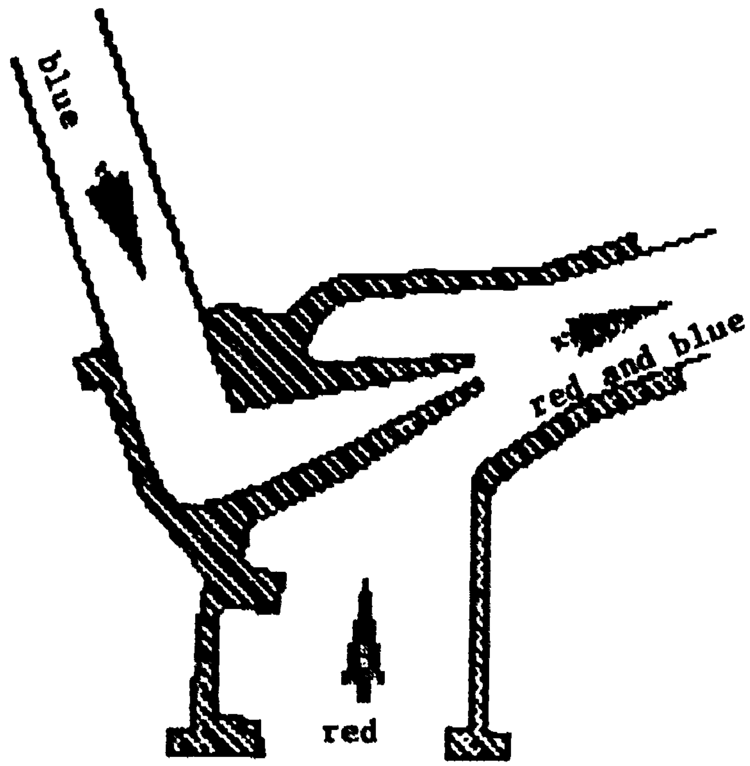
A low pressure area is created from the fuel's velocity increase.

The low pressure area, exposed to fuel in a tank, creates a suction which causes the fuel to be pumped (sucked) out of the tank and transferred elsewhere.

207

blue = Motive flow fuel
red = Transfer tank fuel

This screen has the same text, but there is an animated sequence going on in the graphic. This animated sequence is repeated several times. Note that HELP and BACK are available.



blue = Motive flow fuel
red = Transfer tank fuel

First, pressurized fuel flows through the venturi of an ejector.

A low pressure area is created from the fuel's velocity increase.

The low pressure area, exposed to fuel in a tank, creates a suction which causes the fuel to be pumped (sucked) out of the tank and transferred elsewhere.

WATCH AGAIN

Press NEXT to go on; C to comment on material.

This screen presents an embedded question. It helps ensure that people do not simply skim through the material without learning it.

This screen print shows the question, the answer we entered, and the feedback message for this answer. If the answer had been incorrect, the student typically would have been branched to the beginning of the segment or perhaps to the remedial or review segment that follows on the next two pages.

Press BACK to review

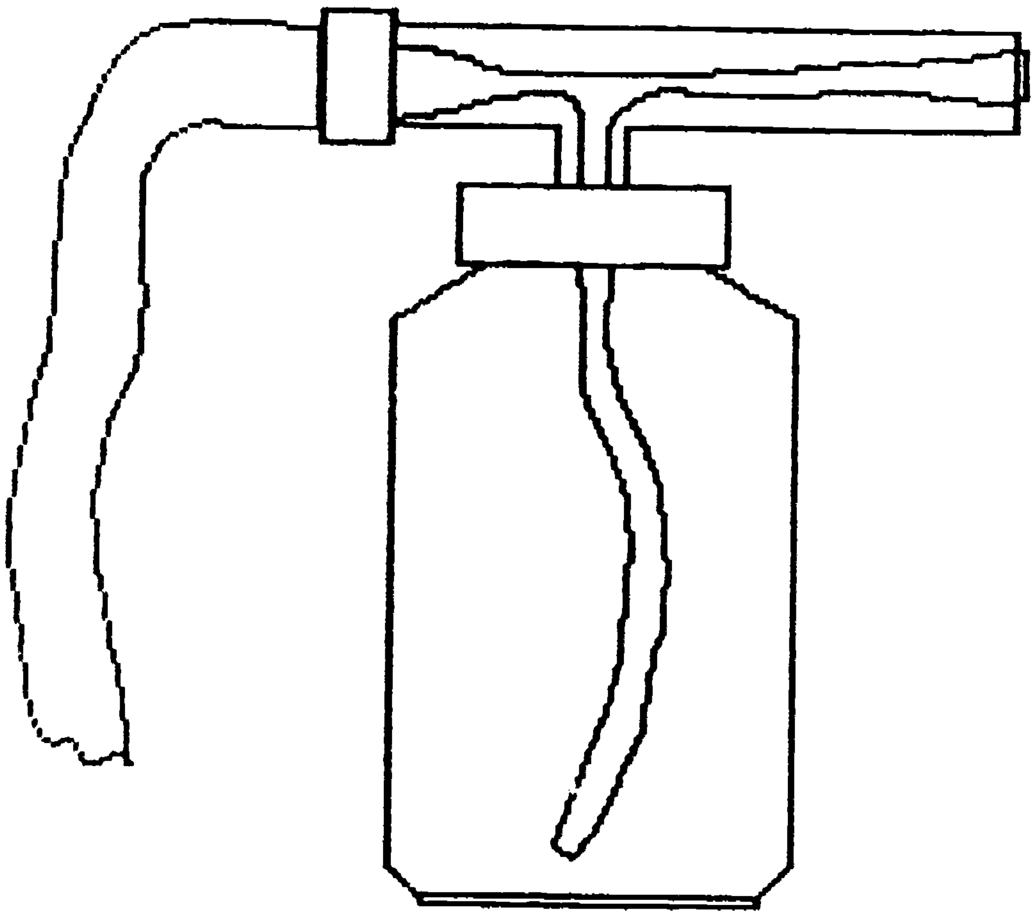
PROGRESS CHECK

The pressure decrease in the venturi provides a low pressure area. What does the low pressure area create?

Enter your response (60 character limit) and press NEXT.
suction

You're right.

This example of review uses the effective instructional technique of teaching by analogy, in this case teaching about motive flow operation with something more familiar to most students: a garden hose sprayer.



The principles used to move fuel in the CF-18 are exactly the same as those used in a common garden hose sprayer.

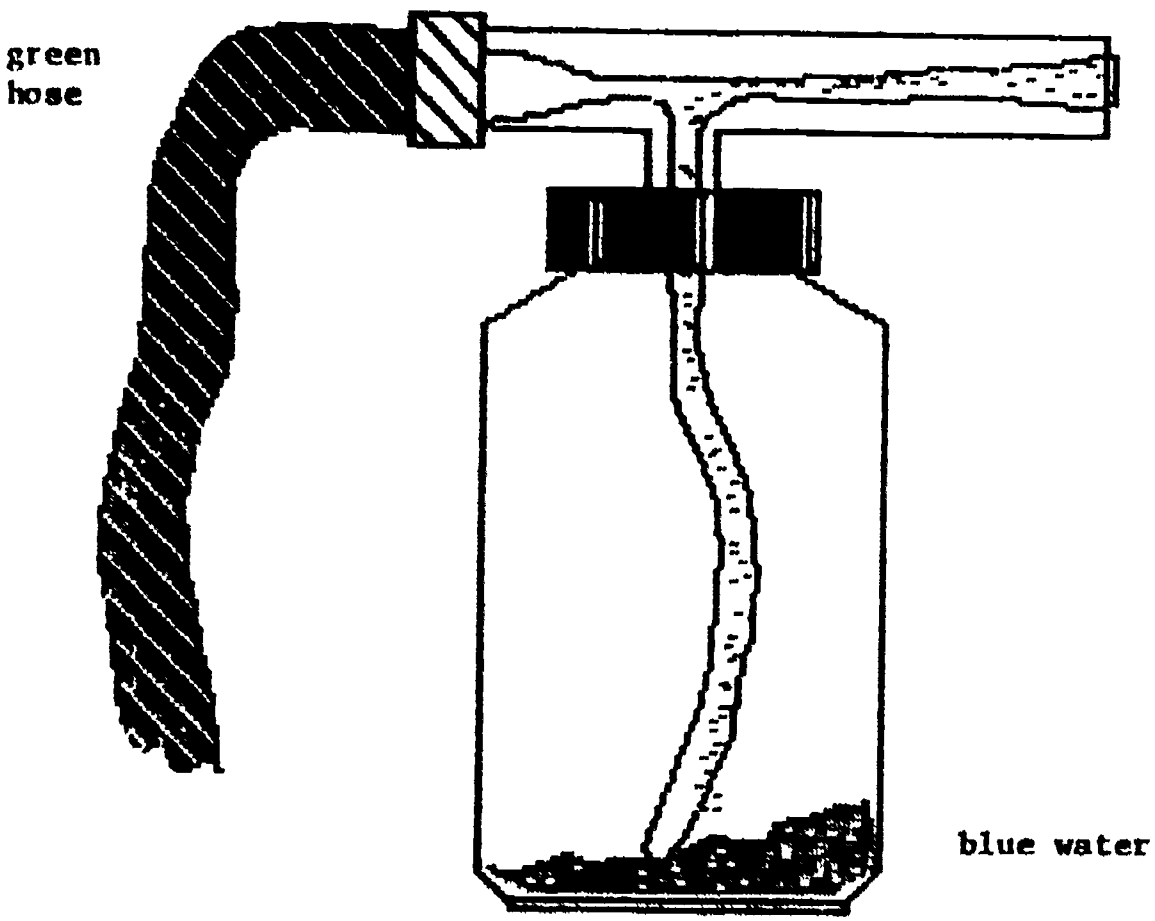
213

NEXT to go to next display
BACK to go to previous display

This screen uses color and animation to demonstrate the action.

Note that the student is required to interact with the program in order to progress through the instructional sequence.

Press BACK to review



Water pressure
enters the sprayer
and is directed
into a venturi.

A low pressure area
is created at the
bottom of the tube
which sucks the contents
of the tank up
and into the stream
of pressurized water.

Touch the graphic
to see the final step.

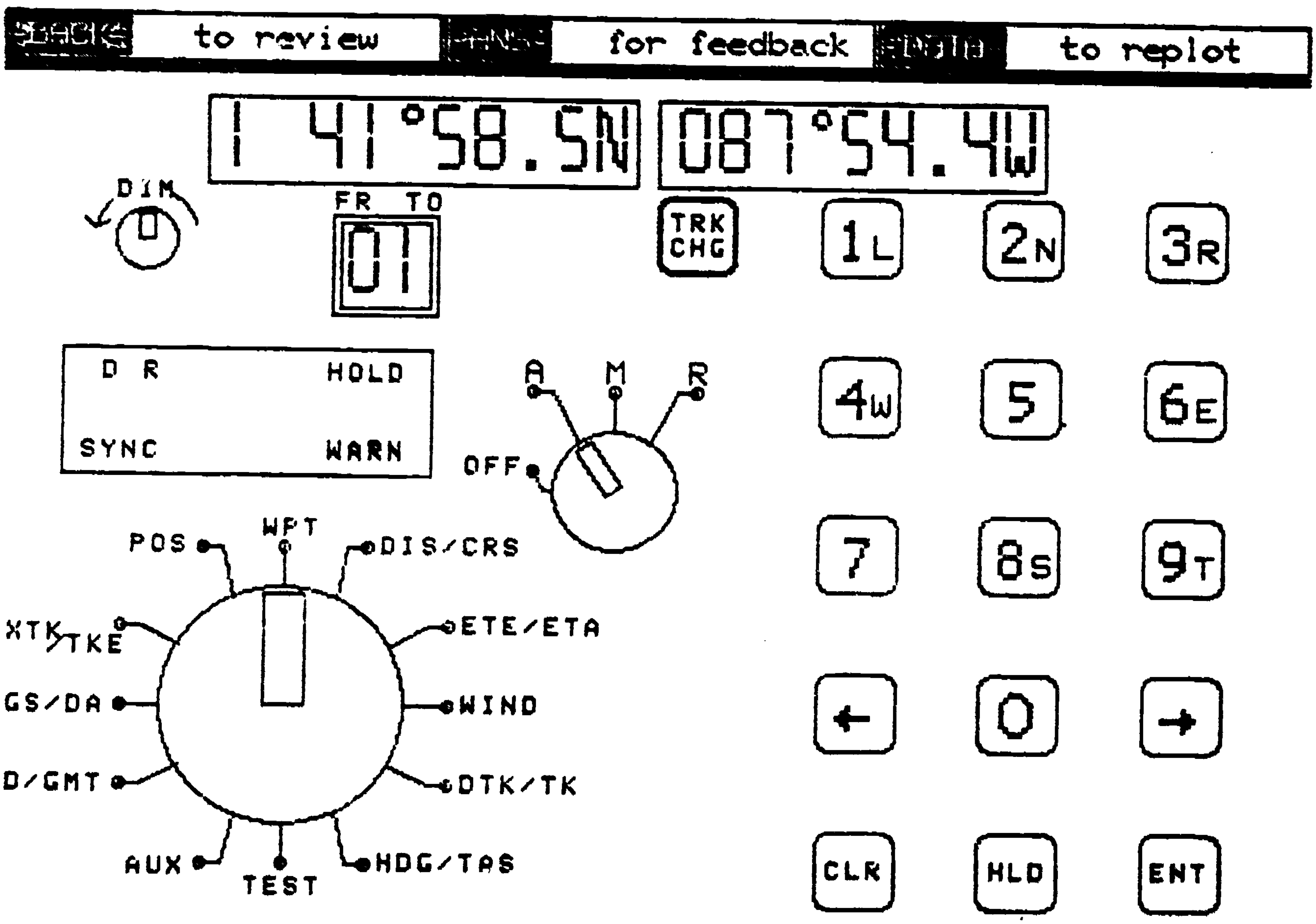
Press NEXT to go on; C to comment on material.

Simulation

Instructional simulations often involve animation and are usually used to depict complex interactions. Flight training is an obvious candidate for simulation because of the scarce and very expensive equipment required to provide pilots with the experience required to do their job. The following sequence exemplifies one of the very sophisticated flight simulators that emulate the cockpit environment. These provide procedural (but not cockpit environment) simulation for pilots. The next three prints show a small part of an instructional procedural simulation for pilots. This simulation sequence requires pilots to perform procedures exactly as they would in the cockpit by changing dials (touching the touch panel) and punching in coordinates and other data (touching keys on the screen's key pad). This instructional simulation has been found to have sufficient fidelity to the actual equipment that it aids in the economical preparation for operating the actual equipment.

You are in the cockpit of your airplane for Flight 45, on the ground at the gate. Perform the steps you feel necessary. The First Officer has entered the current time, the waypoints and position.

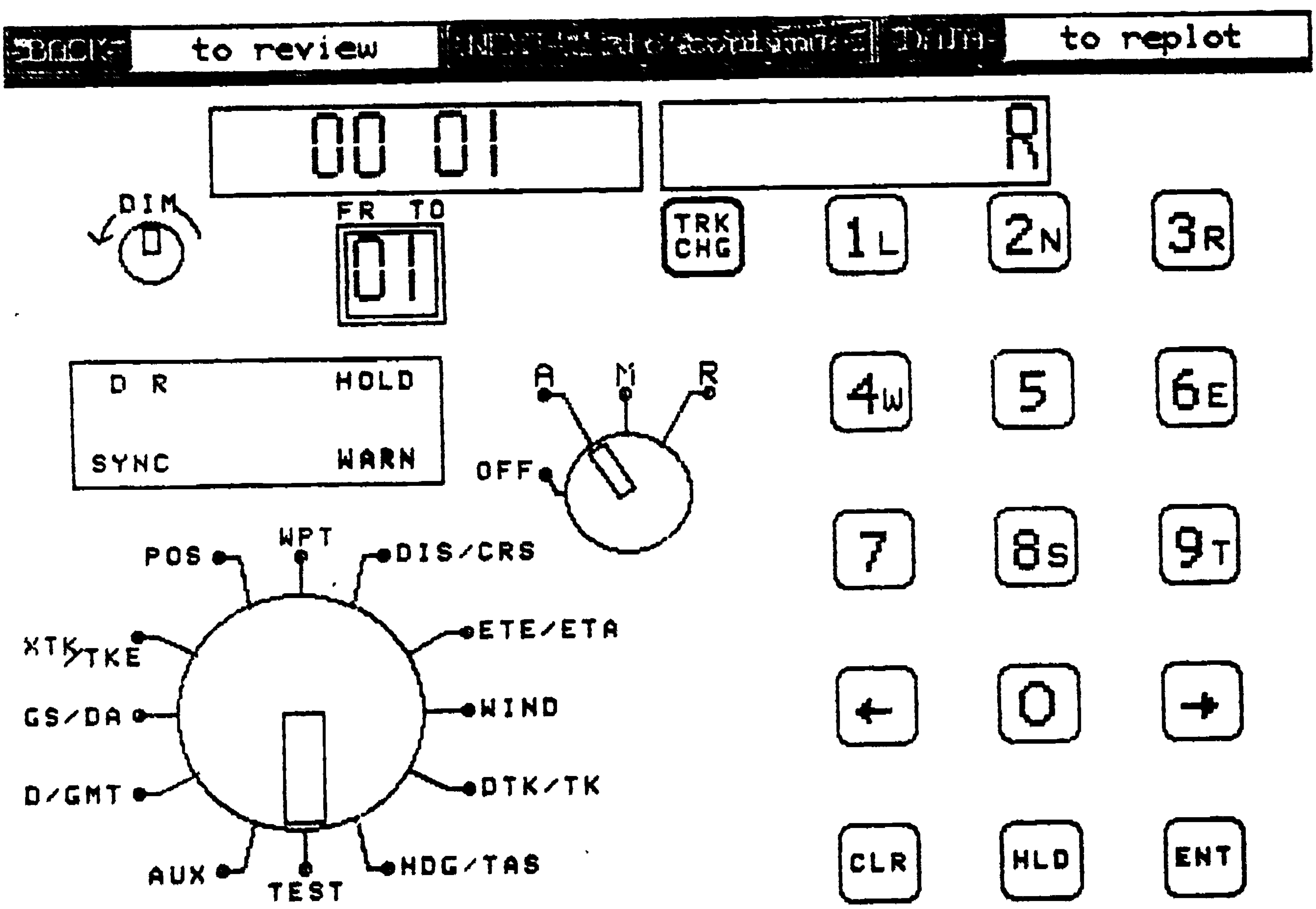
Press the -ANS- key if you are having difficulties.



By permission of the United Airlines Flight Training Center.

You are in the cockpit of your airplane for Flight 45, on the ground at the gate. Perform the steps you feel necessary. The First Officer has entered the current time, the waypoints and position.

Press the -ANS- key if you are having difficulties.

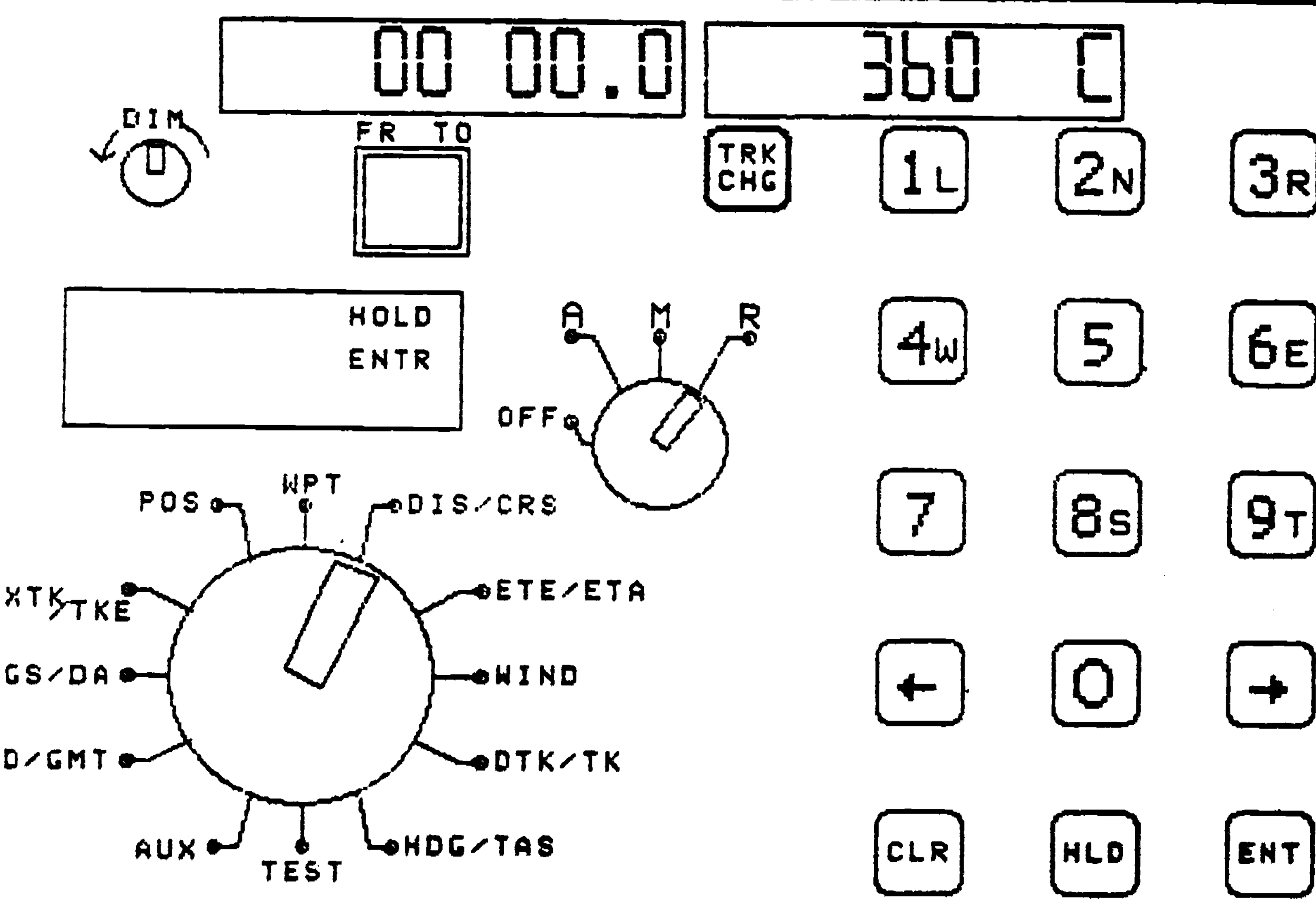


By permission of the United Airlines Flight Training Center.

Perform all the steps you feel necessary prior to departure. The current time is 18:42:00; the date is January 23rd.

NOTAMS indicate that the Navy VLF station in Maryland will be subject to intermittent interruptions for the next 12 hours. Deselect this station.

BACK to review | for feedback | to replot



By permission of the United Airlines Flight Training Center.

Inquiry

The following sequence, provided by United Airlines, is an example of one kind of inquiry CAI in the form of review. There are more sophisticated examples of inquiry CAI available, but they are difficult to depict in paper format. This sequence shows one typical way that pilots can access the material they want: through a series of menus. Suppose a pilot has successfully completed flight training for the 767 aircraft. However, due to the natu-- of the job, the pilot wishes to review materials and procedures for the aircraft using the United Airlines Flight Training Center. CAI, the pilot selects "b," Cockpit Preparation.

UNITED 767 COURSE

- a. Introduction to PLATO/SPT
- b. Cockpit Preparation - Captain
- c. Evacuation/Cockpit Prep - F/O
- d. Final Cockpit Preparation
- e. Engine Start
- f. After Start
- g. Taxi Out
- h. Takeoff
- i. Rejected Takeoff
- j. After Takeoff
- k. Climb
- l. Cruise
- m. Approach/Descent
- n. Final Descent
- o. Go-Around
- p. Landing Roll
- q. Taxi-In
- r. Parking
- s. Miscellaneous
- t. Computations
- u. Irregular Procedures
- v. Emergency Proc. - FRM/FIM
- w. Flight Management System

	BACK to Previous	SHIFT-STOP to leave

By permission of the United Airlines Flight Training Center.

The user further refines his inquiry with this menu. In this instance, "a" is selected.

Cockpit Preparation - Captain

- a. Electrical System to BUS OFF LIGHTS
- b. EXT. LIGHTS to BULK CARGO HEAT
- c. Flight Management System to HYD. PANEL
- d. ANTISKID SWITCH to FUEL HEAT SELECTORS
- e. ENGINE START SELECT to EQUIP COOLING
- f. INDICATOR LIGHTS to TEMP CONTROL SELECT
- g. Autoflight Panel to INSTRUMENT SOURCE
- h. AIRSPEED INDICATOR to ALTIMETERS
- i. VERTICAL SPEED IND. to THRUST REF. SET
- j. EICAS DISPLAY to EEC SWITCHES
- k. STAB. TRIM CUTOUT to RUDDER TRIM
- l. ACARS System to SEAT AND RUDDER PEDALS

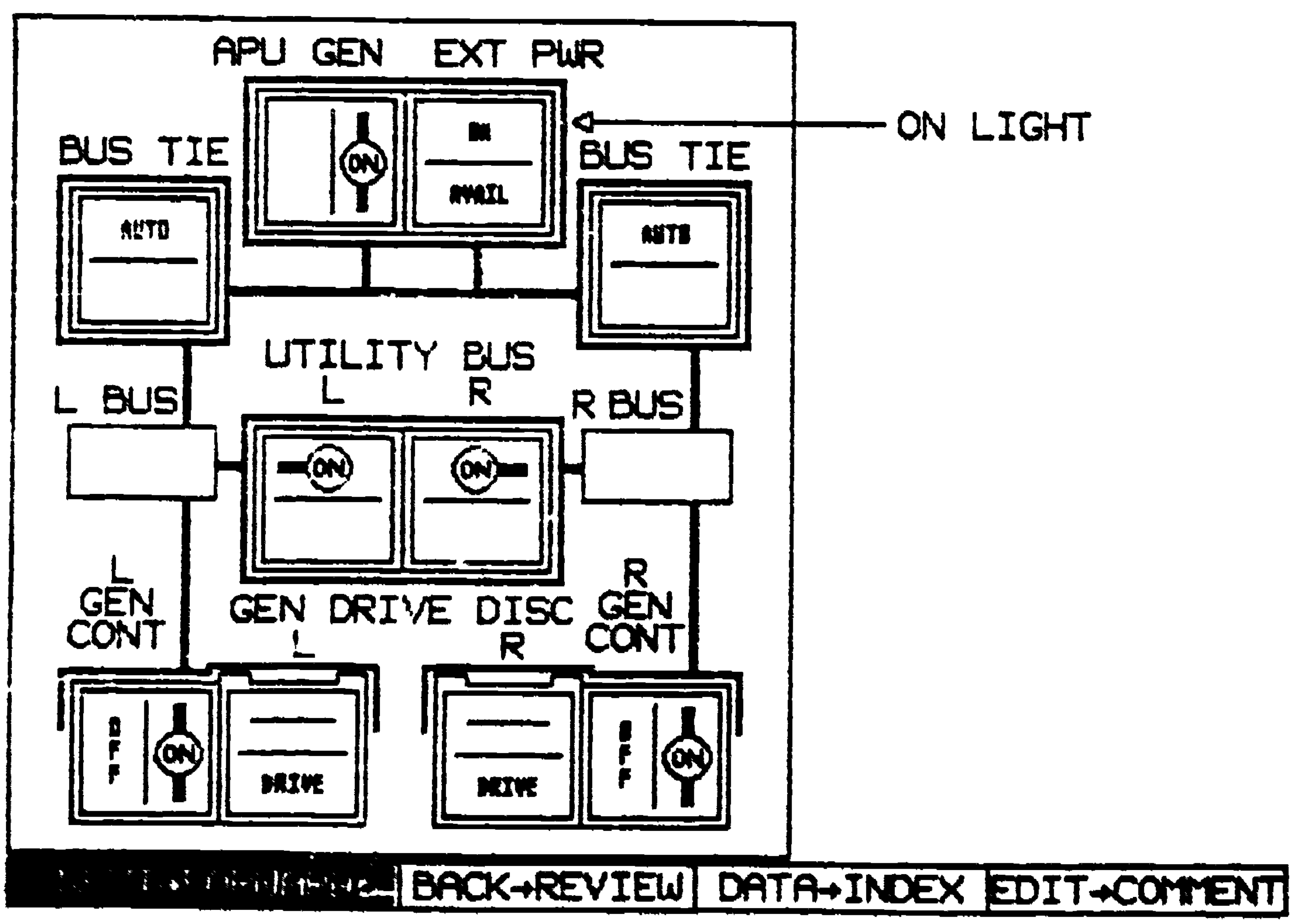
	BACK to Previous	SHIFT-STOP to leave

Deeper into the inquiry, the pilot must select specific information desired, or, in this case, must indicate where in the procedure the review is to start. In this case, "I" is selected. This inquiry can be stopped at any time.

The next four pages are the instruction the pilot has requested. Note on each page the control the user has over the flow of the review (NEXT, BACK, INDEX, COMMENT); this control is a requirement of inquiry.

The ON light in the EXT PWR switch indicates the EPC has closed.

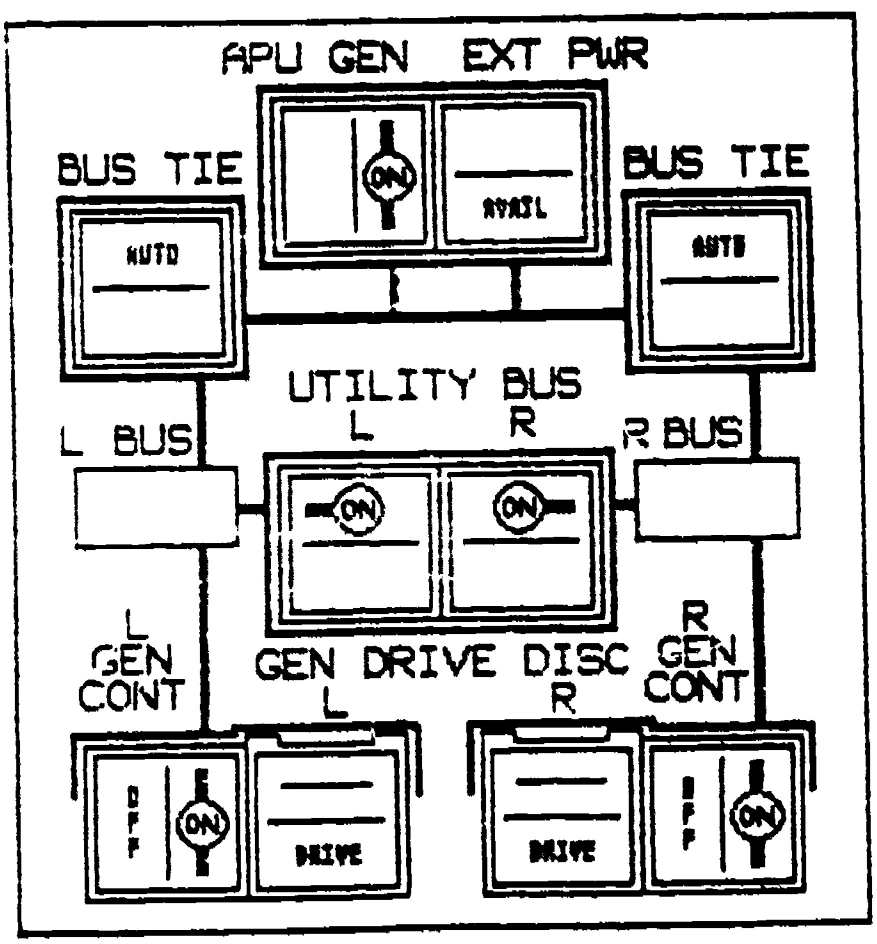
This slide illustrates the electrical system powered by an external source.



By permission of the United Airlines Flight Training Center.

This slide shows the external power contactor (EPC) open and external power available. When the external power switch is pushed any other power source is removed, the EPC closes, and the main buses are powered.

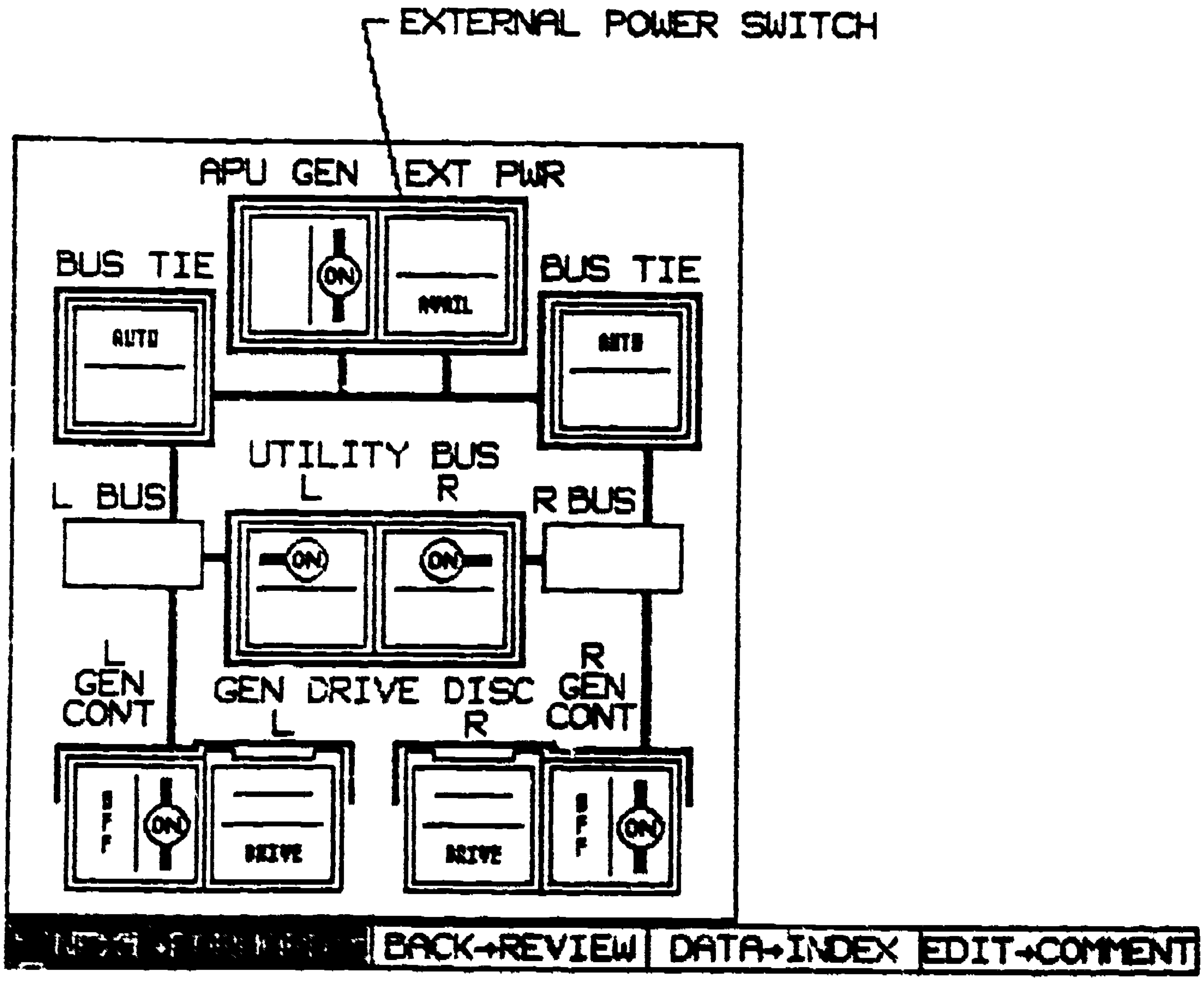
TOUCH the EXT PWR switch to close the EPC.



By permission of the United Airlines Flight Training Center.

EXTERNAL POWER AVAIL LIGHT......CHECK ON

The external power switch is located on the electrical panel. The AVAIL light in the lower half of the switch indicates external power is connected to the airplane and is of usable voltage and frequency.



By permission of the United Airlines Flight Training Center.

Cockpit Preparation - Captain
Electrical System thru BUS OFF LIGHTS

You have completed this material, so you may review any part of it by typing its letter, or you may return to the lesson index by pressing NEXT or BACK.

- a. Electrical System Description
- b. BATTERY SWITCH..........................ON
- c. STANDBY POWER SELECTOR...............AUTO
- d. Hydraulic System Description
- e. HYDRAULIC PANEL........................SET
- f. APU System Description
- g. APU..................................START
- h. APU GENERATOR SWITCH...........VERIFY ON
- i. EXTERNAL POWER AVAIL LIGHT......CHECK ON
- j. EXTERNAL POWER SWITCH..................ON
  Electrical Panel........................Set
- k. BUS TIE SWITCHES.............VERIFY AUTO
- l. UTILITY BUS SWITCHES...........VERIFY ON
- m. L, R, AND UTIL BUS OFF LIGHTS........OFF
- n. Knowledge Test
- o. Procedures Review/Test

NEXT ⇨ Return to the Lesson Index

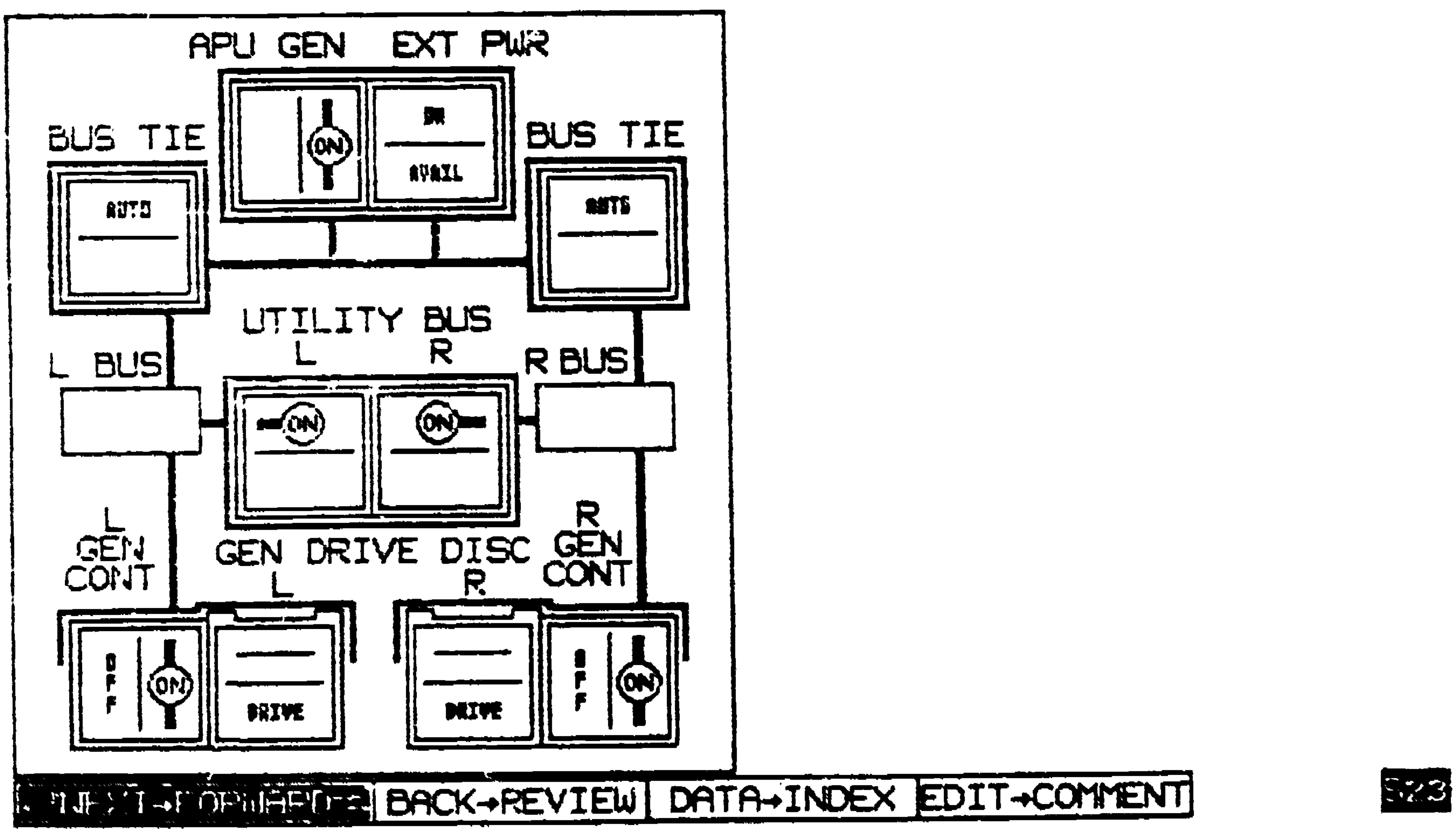
[illegible] | BACK to Lesson index | SHIFT-STOP to leave

By permission of the United Airlines Flight Training Center.

This is the last display the pilot-user wishes to review. After completing the review presented here, the pilot presses the DATA key on the keyboard and is returned to the last index encountered.

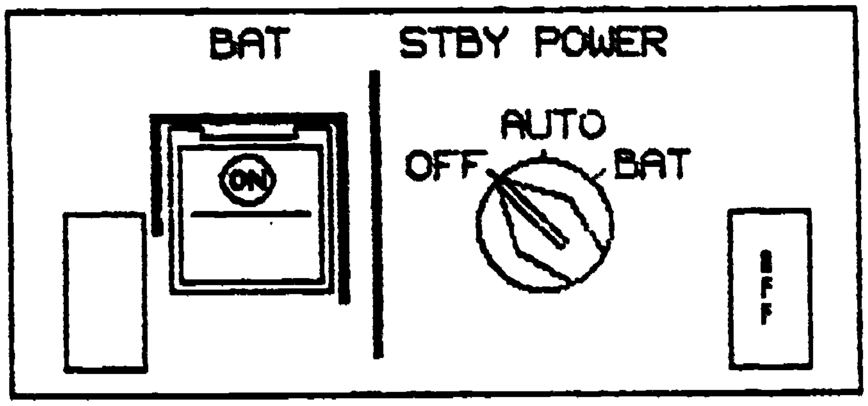
Once the EPC is closed it remains closed unless:

- The external power switch is pushed.
- Both engine generator breakers are closed.
- External power becomes unavailable or is disconnected.
- External power overload occurs.
- A fault on the tie bus occurs.



By permission of the United Airlines Flight Training Center.

After returning to the deepest index encountered before instruction, the pilot may choose to take a test (n and o of menu options) as part of the inquiry. In this sequence the pilot has selected "n." Note that in the following two question-answer examples, feedback is provided.



The airplane is unpowered except that the battery switch is (ON). Are the panel indications shown here correct?

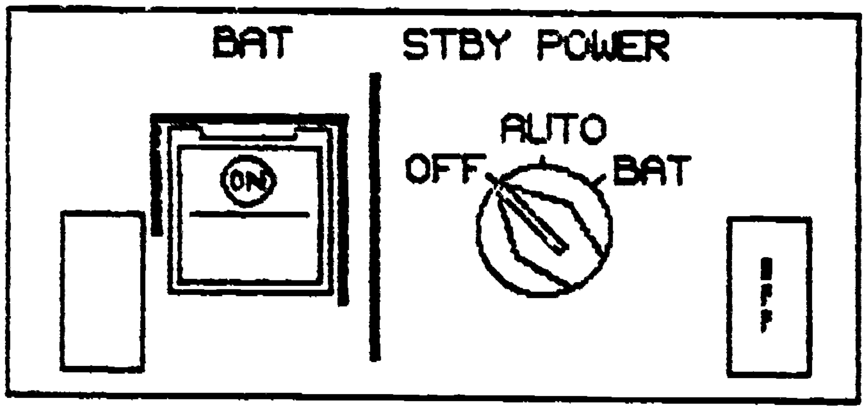
1. Yes, the battery bus loads are not sufficient to cause the DISCH light to come on.

YOUR ANSWER ▶ 2. The standby power OFF light is not powered until the selector is in AUTO or BAT.

CORRECT ANSWER ▶ 3. No.

DATA → INDEX

By permission of the United Airlines Flight Training Center.



The airplane is unpowered except that the battery switch is (ON). Are the panel indications shown here correct?

1. Yes, the battery bus loads are not sufficient to cause the DISCH light to come on.

2. The standby power OFF light is not powered until the selector is in AUTO or BAT.

3. No.

Touch or type your answer.

1	2	3

By permission of the United Airlines Flight Training Center.

Assume no airplane generators or external power are available on the airplane. What buses are powered if the battery switch is off?

[illegible]

1. Hot battery bus only.

2. Hot battery and standby DC buses.

3. Hot battery and all standby buses.

[illegible]	DATA → INDEX	LAB → REVIEW

By permission of the United Airlines Flight Training Center.

Assume no airplane generators or external power are available on the airplane. What buses are powered if the battery switch is off?

1. Hot battery bus only.

2. Hot battery and standby DC buses.

3. Hot battery and all standby buses.

Touch or type your answer.

1	2	3

By permission of the United Airlines Flight Training Center.

Cockpit Preparation - Captain
Electrical System thru BUS OFF LIGHTS

You have completed this material, so you may review any part of it by typing its letter, or you may return to the lesson index by pressing NEXT or BACK.

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NEXT Return to the lesson index

[illegible] | BACK to Lesson index | SHIFT-STOP to leave

E. Selected CAI-Related Civilian Associations and Periodicals

CAI-Related Civilian Associations

American Educational Research Association (AERA)
1126 16th Street, N.W.
Washington, DC 20036
Phone: (202) 223-9485

Founded: 1915

Professional organization of educators and behavioral scientists interested in the development, application and improvement of educational research. Members include professors, state and local school system research directors, research specialists, graduate students of education and educators in foreign countries.

Publications:

1. Educational Researcher, monthly
2. Educational Evaluation and Policy Analysis, bimonthly
3. American Educational Research Journal, quarterly
4. Journal of Educational Statistics, quarterly
5. Review of Educational Research, quarterly
6. Review of Research in Education, annual; Sponsors Encyclopedia of Educational Research (revised every 10 years); Handbook of Research on Teaching (revised every 10 years).

Formerly: (1930) National Association of Directors of Educational Research
Convention/Meeting: annual

Association for Development of Computer-Based Instructional Systems (ADCIS)
Computer Center
Western Washington State College
Bellingham, WA 98225
Phone: (206) 676-2860

Founded: 1968

University, junior college, high school, military and commercial users of computer-assisted and/or -managed instruction. Purposes are to advance the investigation and utilization of computer-assisted instruction systems; promote the interchange of information, programs, and materials in the best professional and scientific tradition; reduce redundant effort among system users; specify requirements and their priorities for hardware and software development, and encourage and facilitate their accomplishment through cooperative projects.

Presents awards. Special Interest Groups: Computer-Based Training; Education of the Deaf; Elementary/Secondary/Junior College; Health; Implementation; Minicomputer Users; Music Consortium; Plato Users.

Publications:

1. Newsletter, bimonthly
2. Journal of Computer Based Instruction, quarterly

Formerly: (1973) Association for Development of Instructional Systems
Convention/Meeting: annual

Association for Educational Communications and Technology (AECT)
1126 16th Street, N.W.
Washington, DC 20036
Phone: (202) 833-4180

Founded: 1923

Audiovisual and instructional materials specialists, educational technologists, audiovisual and television production personnel and teacher educators. To improve education through the systematic planning, application and production of communications media for instruction. Maintains archives of materials and equipment.

Publications:

1. Newsletter, monthly
2. Audiovisual Instruction, 9/year
3. Educational, Communications and Technology Research Journal, quarterly
4. Journal of Instructional Development, quarterly
5. Membership Data Book, annual

Formerly: (1932) National Academy of Visual Instruction
(1947) Department of Visual Instruction
(1970) Department of Audiovisual Instruction

Association for Educational Data Systems (AEDS)
1201 16th Street, N.W.
Washington, DC 20036
Phone: (202) 833-4100

Founded: 1962

Persons involved directly with planning, development and operation of educational data processing systems and the transmission of educational information in machine usable form. Seeks to "promote a greater flow of information among educators and educational administrators regarding data and information processing ideas, techniques, materials and applications."

Publications:

1. Bulletin, quarterly
2. Journal, quarterly
3. Monitor, quarterly
4. Handbook and Directory, irregular
   Also publishes Computer Club handbook, Convention Proceedings and Layman's Guide

Affiliated with: American Federation of Information Processing Societies; Institute for Certification of Computer Professionals

Absorbed: (1978) National Association of Users of Computer Applied Learning

National Society for Performance and Instruction (Programmed Instruction) (NSPI)
1126 16th Street, N.W., Suite 315
Washington, DC 20036
Phone: (202) 833-4178

Founded: 1962

Persons concerned with "achieving effective performance analysis and management, system development and implementation." Members also evaluate the effect of management and management information systems and of support systems and motivation systems when developing and implementing performance systems. Maintains speakers' bureau; sponsors specialized education.

Publications:

1. Journal, 10/year
2. Improving Human Performance, quarterly
3. Official International Directory of Members, biennial

Formerly: (1973) National Society for Programmed Instruction
Convention/Meeting: Annual

Society for Applied Learning Technology (SALT)
50 Culpeper Street
Warrenton, VA 22186
Phone: (703) 347-0055

Founded: 1972

Senior executives from military, academic and industrial organizations which design, manufacture or use training technology, including computer-assisted instruction, simulators, trainers, audiovisual instruction delivery devices and job performance aids. SALT founders and officers report that their objectives are to support, improve, advance and generally contribute to the development of standards and practices in the application of technology to training and to aid and assist individuals, agencies and institutions with respect to the application of training technology to the definition and solution of social and human problems; to facilitate the exchange of information and experience with respect to the current state-of-the-art and with respect to known ongoing efforts directed toward the advancement of the use of training technology; to foster wide dissemination of understanding and knowledge in the actual and potential use of technology in the field of training in order to assure and realize the maximum contribution of this technology to the nation and the world; to provide an effective educational channel among and between scientists, managers and users of training technology both in the private and public sectors in the U.S. with the object of assuring adequate skills, understanding and effective management of training technology. Bestows awards for recognition of outstanding contributions. Conducts seminars. Maintains special interest groups.

Publications:

Journal of Educational Technology Systems, quarterly
Also publishes Conference Proceedings.

Convention/Meeting: semiannual
Also sponsors International Learning Technology Congress and Exposition biennially.

These descriptions taken from Yakes, N., & Akey, D. (Eds.). Encyclopedia of Associations (Vol. 1). Detroit, MI: Gale Research Co., 1980.

CAI-Related Civilian Periodicals

AEDS Journal
1201 Sixteenth Street, N.W.
Washington, DC 20036

Computers and Education
Pergamon Press Ltd.
Headington Hill Hall
Oxford OX3 OBW, England

Creative Computing Magazine
P.O. Box 789-M
Morristown, NJ 07960

Educational Communication and Technology Journal
Association for Educational Communications and Technology
1126 16th Street, N.W.
Washington, DC 20036

Educational Technology
140 Sylvan Avenue
Englewood Cliffs, NJ 07632

Info World
530 Lytton Avenue
Palo Alto, CA 94301

Journal of Computer-Based Instruction
215 South Main
Clarion, IA 50525

Journal of Educational Technology Systems
Baywood Publishing Co., Inc.
120 Marine Street
Farmingdale, NY 11737

Journal of Instructional Development
Association for Educational Communications and Technology
1126 16th Street, N.W.
Washington, DC 20036

CAI-Related Civilian Periodicals

AEDS Journal
1201 Sixteenth Street, N.W.
Washington, DC 20036

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1126 16th Street, N.W.
Washington, DC 20036

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Englewood Cliffs, NJ 07632

Info World
530 Lytton Avenue
Palo Alto, CA 94301

Journal of Computer-Based Instruction
215 South Main
Clarion, IA 50525

Journal of Educational Technology Systems
Baywood Publishing Co., Inc.
120 Marine Street
Farmingdale, NY 11737

Journal of Instructional Development
Association for Educational Communications and Technology
1126 16th Street, N.W.
Washington, DC 20036

Microcomputer News
Benwill Publishing Corp.
1050 Commonwealth Avenue
Boston, MA 02215

Mini-Micro Systems
270 St. Paul Street
Denver, CO 80206

Performance and Instruction
National Society for Performance and Instruction
1126 16th Street, N.W.
Suite 315
Washington, DC 20036

Review of Educational Research
American Educational Research Association
1230 17th Street, N.W.
Washington, DC 20036

T.H.E. Journal
Synergy, Inc.
P.O. Box 992
Action, MA 01720

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