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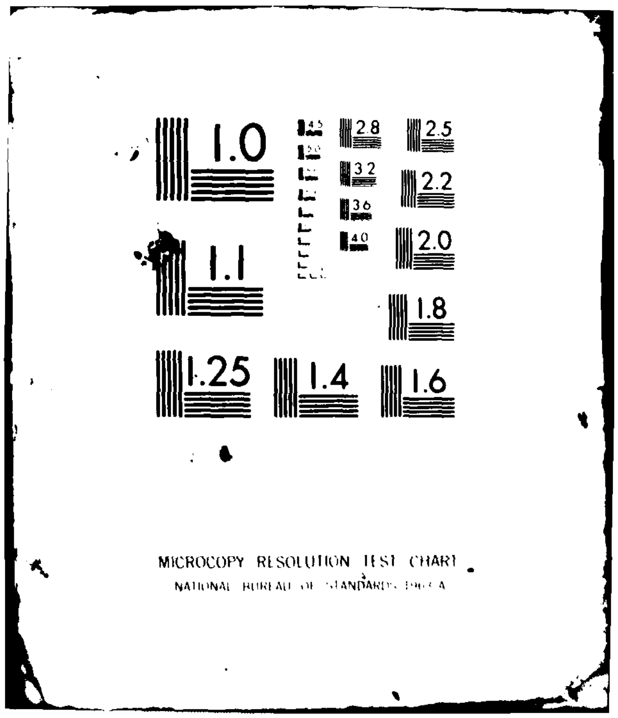
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POTENTIAL APPLICATIONS OF COMPUTER-ASSISTED INSTRUCTION TO P-3 AIRCREW TRAINING

NAVY PERSONNEL RESEARCH AND DEVELOPMENT CENTER SAN DIEGO, CALIFORNIA

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POTENTIAL APPLICATIONS OF COMPUTER-ASSISTED INSTRUCTION TO P-3 AIRCREW TRAINING

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An investigation was undertaken to examine the recently revised P-3 aircrew training syllabus at Patrol Squadron 31 to identify the potential contributions that could be made to training effectiveness by a shift to computer-assisted instruction (CAI). Five areas representing the range of potential applications were examined. The characteristics of existing and potential computer-based systems were reviewed, and recommendations for applications to P-3 aircrew training were made.

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FOREWORD

This effort was conducted in support of reimbursible work unit 98WR96633 (P-3 Aircrew Training Improvement), under the sponsorship of the Chief of Naval Operations (OP-594) and the Naval Air Systems Command (AIR-4133E). The overall objective of the work was to design and develop improved aircrew training for the P-3 Fleet Readiness Squadrons (FRSs) using state-of-the-art instructional development techniques.

This report provides guidelines for the possible future use of computer-assisted instruction (CAI) as a primary instructional delivery medium for P-3 FRS aircrew training. It is intended for use by CNO (OP-594); NAVAIRSYSCOM (AIR-4133E); Commander Naval Air Force, U.S. Pacific Fleet; Commander Naval Air Force, U.S. Atlantic Fleet; Commander Patrol Wings Pacific; Commander Patrol Wings Atlantic; and the two P-3 FRSs, Patrol Squadrons THIRTY and THIRTY-ONE (VP-30 & VP-31), to aid in determining whether and in what way CAI might be a useful medium for delivery of instruction to P-3 aircrew trainees.

The contracting officer's technical representatives were Walter F. Thode and Joseph C. McLachlan.

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Commanding Officer

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Technical Director

SUMMARY

Problem and Background

The P-3 instructional system was designed to provide aircrew readiness training for Patrol Squadrons THIRTY and THIRTY-ONE (VP-30 and VP-31). The training program was initially implemented by VP-31 in October 1978, and full-scale implementation by VP-30 occurred in January 1980. Although the formal evaluation has not been completed, VP-31 personnel agree that the P-3 instructional system provides better aircrew readiness training than the previous program. However, they have identified both general areas of concern and specific problem areas in the curriculum that need to be improved.

Several methods are available to increase training effectiveness and provide solutions to existing shortcomings in the P-3 instructional system. These include changes in the present media mix, more efficient utilization of existing training resources, and revisions to instructional materials. One solution that has been suggested to improve the training effectiveness of the P-3 instructional system is the implementation of computer-assisted instruction (CAI).

Objectives

The purpose of this study was to analyze and compare various CAI systems and the current P-3 media mix to determine the most effective training approach.

Approach

1. Specific areas in the P-3 curriculum where CAI might improve the effectiveness of the training were identified.

2. The number of CAI student stations required to support the initial configuration was determined.

3. The CAI media requirements to support the potential applications identified in Step 1 were determined in terms of display and response characteristics.

4. The media options available for the characteristics required to support the applications were analyzed.

Findings

Based upon interviews with VP-31 personnel, 59.5 hours of instruction were identified in a sample of five courses examined for potential CAI application. The courses examined were those for five aircrew positions: pilot, flight engineer, naval flight officer, acoustic sensor station operators 1 and 2, and nonacoustic sensor station operator 3. Evaluation of the CAI media characteristic requirements indicated that two commercial CAI systems--time-shared interactive computer controlled instructional television (TICCIT) and the General Electric training system (GETS)--can functionally satisfy the identified training requirements. Several other CAI options, which could be developed using existing school resources, were also considered. These include both embedded training on the CP-901 on-board computer, and enhancements to the aviation training support system (ATSS).

Conclusions

Although the potential CAI hours are related to specific problem areas in the curriculum, they can be considered representative of other CAI applications in the training program. By identifying priority areas for initial implementation, CAI can gradually be introduced into the curriculum without overstraining existing resources. However, once the initial capability is available, a number of applications could be developed.

Recommendations

1. Formal evaluation data regarding the effectiveness of the P-3 instructional system should be collected and analyzed to identify revisions required in the aircrew training program.

2. As the evaluation data become available, decisions should be made by users and sponsor concerning the implementation of CAI to improve the effectiveness of the P-3 instructional system. If CAI is warranted, VP-30 and VP-31 should investigate the requirements and costs to develop and support additional embedded training programs on the CP-901 computer, enhance ATSS to include a CAI capability, and support commercial CAI systems.

3. Life cycle costs should be the basis for selecting the alternative to improve the P-3 instructional system, if it is decided to implement CAI.

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INTRODUCTION

Background and Problem

The P-3 instructional system was designed to provide aircrew readiness training for Patrol Squadrons THIRTY and THIRTY-ONE (VP-30 and VP-31). The training program covers three versions of the P-3 aircraft--B Mod, C, and C Update I and II--found in fleet squadrons on the east and west coasts. It is organized into courses or tracks by seven aircrew positions: pilot, flight engineer (FE), naval flight officer (NFO), acoustic sensor station operators 1 and 2 (SS 1/2), nonacoustic sensor station operator (SS 3), ordnanceman, and communicator. The total training program consists of approximately 6,000 learning objectives, which are presented through individualized materials in the learning center, practical exercises in device sessions, and seminars.

The P-3 instructional system was developed using instructional systems development (ISD) procedures. It was initially implemented by VP-31 at the Naval Air Station, Moffett Field, California, in October 1978. Full-scale implementation by VP-30 occurred at the Naval Air Station, Jacksonville, Florida, in January 1980.

Although formal evaluation data have not been collected and analyzed, VP-31 personnel agree that the P-3 instructional system provides better aircrew readiness training than does the previous program. However, they have identified both general areas of concern and specific problem areas in the curriculum that need to be improved. In-house efforts to improve the training in some of these areas are currently underway.

There are several methods to increase training effectiveness and provide solutions to the existing shortcomings in the training program. These include changing the present media mix, more efficient use of existing training resources, and revisions to instructional materials.

The instructional media mix for the P-3 instructional system consists of workbooks, slide-tapes, videotapes, seminars, trainers, simulators, and aircraft. Approximately 70 percent of the objectives are presented in the learning center by workbooks, with some slide-tape or videotape augmentation. In addition, seminars are scheduled (1) during learning center study periods to serve as question and answer sessions and (2) after tests to present updated information on systems or procedures and to allow students to work together on lessons. The remaining objectives are accomplished in device sessions using the aircraft, positional trainers, or simulators. The trainers include cockpit procedure trainers (CPTs) and cockpit familiarization trainers (CFTs) for the pilots and FEs, the tactical navigation (TACNAV) trainer for BNFOs (NFOs in version B Mod), the operational position trainer for the SS 1/2, and several operational position trainers for the SS 3. The simulators include the 2F69E (T), 2F87 (T), and 2F87A (T) operational tactics trainers for the tactical coordinator (TACCO), navigator (NAV), navigator/communicator (NAV/COM), SS 1/2, and SS 3 positions, and the 2F69D(F) and 2F87(F) operational flight trainers for pilots and FEs.

More efficient use of training resources encompasses a variety of factors, the key factor being better training system management tools. Implementation of the aviation training support system (ATSS) should provide better resource use through functions such as course scheduling, testing and grading procedures, and administrative support. It should reduce the time instructors spend performing administrative tasks and increase the time available for seminars and interaction with students. More comprehensive scheduling should allow more hands-on practice in trainers, simulators and aircraft.

The instructional materials might be revised by many ways, such as rewriting test items, including more helps and examples, identifying additional enabling objectives, and changing the media format. One solution that has been suggested to improve the training effectiveness of the P-3 instructional system is to implement computer-assisted instruction (CAI).

Objective

The purpose of this study was to analyze and compare various CAI systems and the current P-3 media mix to determine the most effective training approach. It was determined that each CAI system included in the analysis must be capable of: (1) delivering the instructional materials that are part of the P-3 aircrew training program, (2) accepting curriculum revisions, (3) generating data necessary to manage the training, and (4) being supported by the Navy.

APPROACH

The approach consisted of four steps, which are described in the following paragraphs:

1. Identify potential CAI applications. In this step, specific areas in the P-3 curriculum where CAI might improve the effectiveness of the training were identified. The criteria for selecting potential CAI applications included the following:

   a. Existing workbooks or other media were not meeting the training requirements effectively.

   b. Gaps occurring in the instruction, such as part-task training, might be satisfied by CAI.

   c. There are training resource shortages or scheduling problems, such as instructor time and aircraft, trainer, and simulator availability.

   d. The introduction of CAI might result in more effective use of existing resources, such as time spent in device sessions.

   e. There was a requirement for faster and/or cheaper development and revision of training materials .

2. Determine number of CAI student stations required. In this step, several throughput related assumptions were made to estimate the number of student stations required for an initial configuration.

3. Determine media characteristics required. In this step, the CAI media requirements to support the potential applications identified in Step 1 were determined in terms of display and response characteristics.

4. Determine which media available have required characteristics. In this step, the media options available for the characteristics required to support the applications were analyzed. The media pool was comprised of (a) workbooks and printed materials, (b) slide-tapes, videotapes, and random-access videotape players in the learning center wet carrels, (c) embedded training using the CP-901 processor onboard the aircraft, (d) the ATSS, (e) part-task [illegible] trainers to be developed, (f) commercially available CAI systems, and (g) future CAI system developments.

Initial plans were to include a fourth step--compare costs of media alternatives over expected life cycle. However, formal training program evaluation data from VP-30 and VP-31, as well as further analysis of CAI system options, are required before a comprehensive cost analysis to determine whether CAI should be included in the P-3 media mix can be conducted. A discussion of life cycle cost considerations and methodology is provided in the appendix.

Because of the size of the P-3 instructional system and the scope of the study, it was decided to limit the number of P-3 tracks or courses to be analyzed. First, the ordnanceman and communicator courses were eliminated since they are not emphasized as strongly in the training program. Second, one course was selected for each of the remaining aircrew positions. No selections were necessary for the pilot and FE positions, since there are no distinctions in courses between the P-3 B Mod, C, and C Update I and II versions for these positions. For the NFO, the track for the B Mod version (BNFO) was selected, because instructors were available to participate in the analysis. Finally, for the SS 1/2 and SS 3 positions, the courses for the C version (CSS 1/2 and CSS 3) were selected because of more sophisticated equipment requirements.

The methodology for the study consisted of:

1. Interviews with VP-30 and VP-31 personnel, especially course instructors.

2. Site visits to tour the learning center facilities and observe trainer, simulator, and aircraft device sessions.

3. Extensive review of training materials, especially workbooks and practice booklets.

4. Discussions with CAI system developers and vendors.

The master course syllabus (MCS), which was used to guide the interviews with the instructors, organizes the curriculum into four 25-day phases (A, B, C, and D), each with variable starting dates for specific aircrew position courses. Phase D is the tactics phase in which the different positions, except for FE, form crews for missions in the simulator and aircraft. Since FEs are not involved in tactics, they do not take part in most Phase D activities. Only Phases A, B, and C were reviewed with the instructors to identify units--more specifically, lessons--within the courses where the learning objectives and/or current media mix were considered inadequate.

POTENTIAL CAI APPLICATIONS

In any given training situation, CAI may be an important option to consider for a number of reasons. In an aviation training program as complex as the P-3 aircrew readiness curriculum, the following kinds of considerations may be relevant in selecting CAI as an instructional delivery system:

1. CAI strategies can facilitate learning that requires (a) a large amount of memorization, (b) integration of a variety of learning events, (c) quick access to previously provided information for review and reference, (d) extensive and varied practice, and (e) multiple problem-solving modes.

2. CAI can ensure mastery of learning objectives due to its capability for immediate feedback and remediation.

3. In a part-task simulator mode, CAI can increase efficiency and augment instruction in positional trainers and weapon system trainers when (a) trainer resources are insufficient to meet instructional requirements, and (b) students need remediation or refresher training in some of the tasks ordinarily accomplished in the trainer.

4. In some configurations, CAI can be used for complex tactical simulation scenarios to allow development and practice of skills that might be precluded by limited aircraft and/or trainer availability.

5. CAI can facilitate the management of a large training system by (a) standardizing instructional events, (b) providing a variety of formats for testing and recording scores, (c) starting student history and performance data, and (d) providing diagnostic and prescriptive information.

However, the interaction between the tasks to be trained, available media alternatives, system support requirements, and other instructional and management resources determine whether CAI should be included in the media mix and, if so, what characteristics the CAI system must have.

Since the parameters for improving the training in each course in the P-3 curriculum differ, the requirements for CAI vary on a course-by-course basis. However, by generalizing potential applications across the five courses, implementation of a baseline CAI system with possible expansion capabilities may be an attractive media alternative for improving P-3 training. In analyzing different application areas, several basic types of CAI scenarios that can meet existing problems, as well as provide a framework for more extensive and complex applications at a later time, were identified. These include:

1. Simulation of buttons, switches, keyboards, and other control panel inputs to produce appropriate outputs for simulated display screens, alphanumeric displays, and lights.

2. Use of dynamic graphics to simulate control panel input devices, displays, and indicators to illustrate their relationships to complex electrical or mechanical components.

3. Conversion of existing workbook and video training materials to an interactive format to allow remedial instruction and feedback at each step in the learning process.

4. Development of on-line review and glossary functions so that information (i.e., help, review) is available upon touch and/or keyboard input to facilitate integration of knowledge introduced in earlier lessons.

It should be noted that, as more pieces of equipment are simulated on a CAI system, it is possible to develop scenarios to teach more complex procedures involving several pieces of equipment from one or more stations. Simulation of equipment for initial familiarization with hardware, software, and procedures also permits later development of more complex tactical training scenarios. Specific CAI applications for the courses analyzed are described in the following sections.

Pilot Course

Interviews with pilot instructors revealed that the problem areas in the course were concentrated in Phase A, particularly in Unit 1. A major problem is that students do not understand how complex systems--such as the propeller, fuel supply, electrical, and hydraulic systems--function. This creates problems when the students go into the cockpit procedures trainer (CPT) device sessions, because time must be spent explaining system operation rather than practicing procedures. Although it takes from 1 to 2 years of experience to acquire complete system knowledge, improvements in the early stages of training would be valuable in improving later pilot performance, particularly in situations where multiple malfunctions or emergencies occur and routine procedures must be supplemented by judgment based on system knowledge.

The instructors considered that the instruction involving the interactions between the pilot's controls/indicators and complex systems could be improved. Part of the current problem in teaching complex system operation centers on limitations in the graphics. The workbooks are characterized by simplistic illustrations or no graphics, while the diagrams and schematics from Naval Air Training and Operating Procedures Standardization (NATOPS) program manuals are too complex to illustrate particular concepts. The ability of CAI to present dynamic graphics to illustrate specifics of electrical distribution, hydraulics, fuel flow, and propeller system operation could lead to a more effective understanding of these complex systems. In particular, it would be useful to integrate pilot procedures in a part-task simulation with dynamic graphic illustrations to show the effects of specific inputs on system function. For example, static graphics from specific workbook lessons could be replaced by CAI dynamic graphics and integrated with the appropriate pilot controls/indicators and associated procedures. The control/indicator displays could also be used to practice procedures, as well as to illustrate system function. The aspects of the propeller, fuel, and electrical systems and the associated controls/indicators that could be implemented on CAI as well as the workbook lessons in which they are now taught are listed in Table 1. Based on the number of hours specified for each workbook lesson, a total of 12.5 hours of CAI would be involved for these potential applications.

BNFO Course

Analysis of the BNFO course concentrated on specific lessons in Unit 2 that lead to the first device session in the 2F69 trainer and, eventually, to the initial navigation flight. BNFO instructors reported problems in both the device session and initial flight because the students are not sufficiently familiar with the equipment and procedures and do not understand the overall system signal flow and component relationships. The problems are due to a lack of opportunity for students to engage in hands-on practice. The current media format--workbooks--emphasizes memorization of equipment features and procedures rather than interactive manipulation of real or simulated systems. In addition, workbooks are used to present system signal flow concepts and the details of how each system component functions and interacts with other components. As a result, time is often spent in the device sessions explaining these relationships rather than practicing procedures.

In Unit 2, the students are introduced to several complex hardware/software systems and associated procedures. The primary systems are the LTN-72 inertial navigation system and the ASN-124 navigation computer. Lessons for both these systems involve memorization of complex pieces of equipment and associated procedures. Basically, the students have to memorize tables detailing (1) components and their functions, power sources, circuit breakers, and locations, (2) the effects of different switch settings, buttons, keyboard inputs, etc., (3) the meanings of display mnemonics and symbology, (4) signal flow, and (5) procedural steps involved in using the equipment. With CAI, system controls and display indicators could be simulated on one or more display screens with touch-sensitive or cursor-positioning input devices. The initial simulation could be for famliarization training only, with the potential for augmentation to incorporate more complex procedures and/or tactical scenarios found in later units.

Table 1

Potential CAI Applications for Pilot Course

Systems and Controls/Indicators	Workbook Lessons
Electrical System (5.0 hours)	
Electrical power control panel	Unit 1/Lesson 3/Segment 4
Electrical bus distribution system	Unit 1/Lesson 4/Segment 3
Fuel System (3.0 hours)	
Engine fuel system flow schematic and closeup views	Unit 1/Lesson 11/Segment 2
Parallel lights	Unit 1/Lesson 11/Segment 3
Fuel management panel and closeup views	Unit 1/Lesson 11/Segment 3
Propeller System (4.5 hours)	
Propeller pump housing components	Unit 1/Lesson 15/Segment 2
Propeller control assembly	Unit 1/Lesson 15/Segment 3
Center instrument panel	Unit 1/Lesson 15/Segment 4
RPM/auto feather control/ synchrophase control panel	Unit 1/Lesson 15/Segment 5
Negative torque sensing system	Unit 1/Lesson 16/Segment 1
NTS/feather valve switch and lights	Unit 1/Lesson 16/Segment 2
Prop feather panel and feather buttons on flight station overhead control panel	Unit 1/Lesson 17/Segment 1
Emergency shutdown handles	Unit 1/Lesson 17/Segment 2

Table 2 summarizes potential CAI applications for the BNFO course. Based on the number of hours specified for the workbook lessons, these would be equivalent to approximately 21.0 hours of CAI.

FE Course

Interviews with FE instructors indicated that one of the major shortcomings of the current instruction is in the presentation of system malfunctions and emergency procedures in Unit 5. Revisions to the curriculum to integrate normal procedures and malfunctions/emergency procedures from lessons in Units 4 and 5 into the same workbooks are in progress. These lessons currently use a number of videotapes to augment the workbooks. One recurring problem with the use of videotapes is that they are time-consuming and expensive to revise as NATOPS procedures are revised.

The instructors believed that a more interactive CAI type format would produce better student performance. This could entail reformatting to use the interactive videotape capability now in the learning center wet carrels, converting entirely to computer-stored-and-generated graphics or, perhaps, eventually using new and existing materials to produce an interactive videodisc. A careful examination of all videotapes would be required to determine which approach--interactive video or computer-generated graphics--would provide optimum CAI capabilities.

Table 2

Potential CAI Applications for BNFO Course

Systems and Procedures	Workbook Lessons
LTN-72 inertial navigation system Control display unit Inertial compass system controller Mode selector unit	Unit 2/Lesson 8
ASN-124 navigation computer hardware Digital display indicator Keyer control ASA-66 Converter interface Tactical display control	Unit 2/Lesson 9
ASN-124 software	Unit 2/Lesson 10
ASN-124 navigation procedures	Unit 2/Lesson 11
Navigation mode determination	Unit 2/Lesson 15

Based on a preliminary review, 18 videotapes covering approximately 3.0 hours of instruction were identified in Unit 5. Table 3 provides the title and length for each of the videotapes. Since converting these videotapes to an interactive CAI format might increase the time, a total of 6.0 hours of CAI was assumed.

CSS 1/2 Course

The SS 1/2 instructors indicated that the major problem in the CSS 1/2 course is that the equipment function and gram analysis are not integrated until Unit 9. which concerns tactics. If a CAI system were implemented for SS 1/2 training, they could be integrated throughout the course and interactive practice with feedback could be provided much earlier in the course than Unit 9.

Units 2, 5, and 7 focus on equipment functions, procedures, malfunction identification, and preflight tests through the use of workbooks, videotapes, and aircraft device sessions. Currently, the instructors try to incorporate a gram analysis orientation into the device sessions for these units. Instructors identified Unit 5--particularly those lessons in which malfunctions are identified through system signal flow--as a continuous problem for the analysis of grams later in the course. Although lessons in Units 2, 5, and 7 seem amenable to CAI part-task training to provide hands-on practice and feedback, they were not considered to be priority CAI applications. Instead, priority CAI applications centered on more examples and practice in gram analysis and LOFAR math. Units 3, 4, and 6 focus on gram analysis procedures through the use of workbooks, videotapes, seminars, and device sessions in the 14B44 positional trainer. Instructors stated that there was a real requirement to incorporate practice in applying LOFAR math, presented in Unit 3/Lessons 9 and 10, into subsequent gram analysis lessons and positional trainer device sessions. Adding 1 hour of CAI instruction prior to the device sessions in Units 4 and 6 gives for a total of 8.0 CAI hours for the lessons listed in Table 4.

Table 3

Potential CAI Applications for FE Course

Workbook Lesson (Unit 5)	Videotape Title	Number	Length of Videotape (Minutes)
Lesson 1	Engine start malfunctions	VN086	14.5
Lesson 2	Emergency shutdown	VN011A	10.0
Lesson 3	TIT malfunction	VN076	5.5
Lesson 3	Engine decouple malfunction	VN053	4.0
Lesson 4	Pitchlocked propeller	VN040	8.0
Lesson 4	Propeller malfunctions during takeoff	VN107	8.5
Lesson 7	Generator reset procedures	VN038	6.0
Lesson 7	APU inflight operations	VN074	5.5
Lesson 8	Unsafe gear indication and landing	VN061	7.0
Lesson 8	Gear extended without hydraulic power	VN062	3.0
Lesson 8	Gear extended without electrical power	VN063	3.0
Lesson 10	Flight surface de-ice	VN072	5.5
Lesson 11	Smoke and fume elimination (C)	VN041	4.5
Lesson 11	Smoke and fume elimination (B Mod)	VN042	5.0
Lesson 11	Fire of unknown origin	VN043	8.0
Lesson 12	Special "insight" report on P-3 ditching	VN236	60.0
Lesson 12	Bailout	VN001	10.0
Lesson 12	P-3 ditching procedures	VN002	10.0
Total			178.0

Table 4

Potential CAI Applications for CSS 1/2 Course

Topic	Workbook Lessons
Surface vessels	Unit 4/Lesson 1
U.S. diesel submarines	Unit 4/Lesson 2
Foreign diesel submarines	Unit 4/Lesson 3
Soviet Type 1 diesel submarines	Unit 4/Lesson 4
Soviet Types 2 and 3 diesel submarines	Unit 4/Lesson 5
U.S. nuclear submarines	Unit 4/Lesson 6
Soviet Type 1 nuclear submarines	Unit 4/Lesson 7
Soviet Types 2, 3, and 4 nuclear submarines	Unit 4/Lesson 8
Long-range search and passive localization	Unit 6/Lessons 1-4
Short-range passive and active localization	Unit 6/Lessons 6-7

CSS 3 Course

Interviews with SS 3 instructors indicated that the major problems in the CSS 3 course focused on resource availability. There were problems with positional trainer (14B40) availability to practice system operations and with aircraft availability for device sessions covering system preflight procedures. In addition, safety requirements (i.e., radiation) often preclude using the aircraft for training.

Based on this information, training materials from Units 3, 5, and 6, covering radar, identification friend or foe (IFF), the intercommunication system (ICS), magnetic anomaly detection (MAD), submarine anomaly detection (SAD), and electronic support measures (ESM), were reviewed. As shown in Table 5, a total of 45.0 hours of instruction in device sessions using either the 14B40 positional trainer or aircraft was identified as potential applications for CAI, depending on instructor priority ratings.

Although it would not be desirable to replace all trainer or aircraft practice time with CAI simulations, these simulations could provide backup practice when trainer or aircraft are not available. Therefore, approximately 25 percent of the total 45.0 hours, or 12 hours, are suggested for CAI as tryout to minimize availability problems. These CAI hours could be selected to provide backup practice for several lessons or they could be distributed as parts of a number of lessons, depending on instructor priority ratings.

Table 5

Potential CAI Applications for CSS 3 Course

Unit	Device Session	Title	CAI Hours
3	II	Radar & ICS checks	3.0
	III	Radar/IFF checks	3.0
	IV	Radar checks & adjustments	2.0
	V	Radar operations	3.0
	VI	Radar/IFF operations	3.0
	VII	Off-line operations	3.0
5	XIII	MAD operation	2.0
	XII	MAD/SAD preflight	2.0
	XIV	MAD compensation	3.0
6	XV	ESM practice 1	3.0
	XVI	ESM practice 2	3.0
	XVII	ESM practice 3	3.0
	XVIII	ESM practice 4	3.0
	XIX	ESM practice 5	3.0
	XX	ESM practice 6	3.0
	XXI	ESM practice 7	3.0
Total			45.0

Summary

The CAI applications for the five courses, which are summarized in Table 6, represent specific areas in the P-3 instructional system that need to be improved. CAI is only one method to achieve an improvement in the level of training. However, the rationales for selecting these 59.5 hours, which range from the requirement for student interaction to the lack of training and aircraft availability, illustrate the versatility of CAI, especially when used in a simulation mode. If CAI capability is included in the P-3 instructional system media mix, the potential for applications across courses is significantly larger in scope and size than the potential applications listed in Table 6.

Table 6

Summary of Potential CAI Applications

Course	Unit/Lesson	Topic	CAI Hours
Pilot	1/3	Electrical system components	12.5
	1/4	Electrical power distribution	
	1/11	Engine fuel system	
	1/15	Propeller system components	
	1/16	Propeller system protective devices	
	1/17	Propeller system feathering and unfeathering	
BNFO	2/8	LTN-72 inertial navigation system	21.0
	2/9	ASN-124 navigation computer hardware	
	2/10	ASN-124 software	
	2/11	ASN-124 navigation procedures	
	2/15	Navigation mode determination	
FE	Unit 5	Malfunction and emergency procedures (videotapes)	6.0
CSS 1/2	4/1	Surface vessel classification	8.0
	4/2	U.S. diesel submarines classification	
	4/3	Foreign diesel submarines classification	
	4/4	Soviet Type 1 diesel submarines	
	4/5	Soviet Types 2 & 3 diesel submarines	
	4/6	U.S. nuclear submarines classification	
	4/7	Soviet Type 1 nuclear submarines	
	4/8	Soviet Types 2, 3, & 4 nuclear submarines	
	6/1-4	Long range search and passive localization	
	6/6-7	Short-range passive and active localization	
CSS 3	Unit 3	Radar/IFF device sessions	12.0
	Unit 5	MAD device sessions	
	Unit 6	ESM device sessions	
Total			59.5

CAI STUDENT STATIONS AND MEDIA REQUIREMENTS

Student Station Requirements

Three steps were used to compute the number of student stations required to support the CAI applications listed in Table 6.

1. The total number of student terminal-hours was calculated by multiplying the number of CAI hours in each course by the number of students in a class for each course and summing the totals. In this case, a figure of 741 student terminal- hours was derived by multiplying the number of CAI hours for each course shown in Table 6 by the 1979 student quotas for each aircrew position. It was assumed that the quotas would be the same for the courses for the other versions of the aircraft and that the numbers would not change in the future.

2. The parameters affecting the availability of both students and terminals were examined. These parameters relate to the planned daily use of the terminals, the daily activities scheduled for each course in the master course syllabus (MCS), the number of student users for any given MCS day, and scheduling flexibility or constraints. In this case, the applications listed in Table 6 occur during each 25-day phase of the MCS. Even distribution across the 25 days was assumed with a maximum usage of 6 hours per day per student. Thus, the 741 student terminal-hours were divided by 25 MCS days to give approximately 30 student terminal-hours per day. This figure was then divided by 6 student hours per day to arrive at an initial configuration of five terminals to support 741 student terminal hours.

3. Finally, contingency requirements that could impact the number of terminals were examined. Examples include downtime, fluctuations above planned student quotas, the need to schedule on a group basis, and instructor authoring/revision requirements. Therefore, an additional terminal, for a total of six at each location, was included in the recommendation for the initial configuration.

If it is decided to implement CAI at VP-30 and VP-31, a more precise analysis should be conducted to determine the number of student stations. Suggested precedures for this analysis are as follows:

1. The MCS days on which CAI use is planned should be identified. This involves looking at each day across phases and courses to determine the number of hours of CAI per MCS day. For example, MCS day 15 might show 4 hours in Phase A for the pilot course and 2 hours in Phase C for the CSS 3 course.

2. The number of student terminal-hours per MCS day would be calculated to determine average and peak terminal usage. This involves multiplying the number of students in a class by the number of CAI hours. Using the previous example for MCS day 15:

(4 hours/pilot course x 18 students/class)+(2 hours/CSS 3 course x 6 students/class)
= 72 + 12 = 84 student terminal hours/MCS day 15.

3. The number of terminals would then be calculated by dividing the student terminal hours per MCS day by the number of hours the terminals are available per day. Continuing the example, if it is assumed that MCS day 15 reflects peak terminal usage with the highest number of student terminal hours and the terminals are available 6 hours per day, then:

$$\frac{\text{84 student terminal hours/day}}{\text{6 hours/day}} = \text{14 terminals.}$$

4. The final step would consist of determining whether the peak usage can be leveled through judicious scheduling, such as increasing the daily terminal availability or rescheduling lessons to reduce the CAI hours per day. The impact of contingency requirements, such as downtime and authoring time, should also be reviewed to determine the optimum number of terminals.

CAI Media Requirements

The potential applications listed in Table 6 impose media requirements on any CAI systems considered for acquisition. Therefore, the instructional delivery characteristics required to satisfy the training requirements must be defined. For this study, the CAI media requirements were derived from the requirements for equipment operation simulation.

Table 7 lists the CAI media requirements by two major categories--display capabilities and student interaction features. Each major category is defined in terms of capabilities that are required for specific applications and those that would be desirable (i.e., they would provide flexibility for a broader range of training tasks). In some cases, the desirable features present alternative implementations of similar capabilities. For example, off-screen touch points, interfaces with three-dimensional mockups, and custom keyboards are all ways to provide student interaction with varying levels of fidelity. In other cases, the desirable features represent an additional capability, such as random-access video for computer-generated displays, which might be more cost or training effective in certain situations. The requirements within each category are described below.

Display Capabilities

1. Color. Some kind of color capability--whether achieved through video, computer graphics, microfiche, or other media--under computer control would be required in most of the training identified. The most obvious requirement for color would be in reformatting videotape and slide-tape programs into an interactive video format, as in the FE course. The complex dynamic graphics for the pilot course would also require color to demonstrate system flow and operation. In addition, color would be preferable for simulating various instrument panel indicators and useful for highlighting, color coding, and other general instructional uses.

Although a full range of color capabilities is easily provided by video and photographic media, the question of color computer graphics involves closer attention to cost and effectiveness in supporting specific training applications. If a system can provide both computer graphics and video/photographic outputs, monochrome computer graphics may be sufficient for most applications. A limited range of computer-generated colors might be desirable to increase the power of the system, but specific applications would have to be traded against the increased cost (mainly for additional computer display memory).

2. Line Drawings. Most of the applications discussed would require at least a minimal amount of static line graphics. In some cases, it might be possible to translate workbook graphics directly into a video, computer CRT, or plasma display format, but many of the graphics would probably have to be reformatted to fit the characteristics of the CAI displays. Direct input of previously developed drawings could be supported by either a video medium or a digitizer system. Line drawings could also be developed by a variety of computer graphics software packages.

Table 7

CAI Media Requirements for Potential CAI Applications

Media Requirement	Required	Desirable	Applications: Major	Applications: Additional
Display Capabilities				
Color	x	--	All courses	--
Line Drawings:				
•Static	x	--	All courses	--
•Dynamic	x	--	Pilot	--
Symbology:				
•Static	x	--	NFO, pilot, & SS 3	--
•Dynamic	x	--	NFO	--
Video/photographic:				
•Static	x	--	SS 1/2	All courses
•Dynamic	x	--	FE	--
Resolution	NTSC/512 x 512	High resolution	All courses--NTSC	Pilot--high resolution
Interactive Features				
Touch Inputs:				
•On-screen	x	--	NFO, pilot, & SS 3	All courses
•Off-screen	--	x	NFO, pilot, & SS 3	All courses
Interface to 3-D mockup	--	x	NFO, pilot, & SS 3	All courses
Custom keyboard	--	x	NFO, pilot, & SS 3	All courses
ASCII keyboard	x	--	All courses	--
Random-access video/ photography	--	x	All courses	--

Dynamic line graphics are especially important in the pilot course, where they would be used to develop greater comprehension of complex electrical, fuel, hydraulic, and propeller systems. This could be accomplished effectively through computer animation programs or by using transparency overlays on a color CRT to illustrate, for example, fuel or signal flow by backlighting areas on the transparency in different colors.

3. Symbology. Equipment simulation applications, particularly for the NFO and SS 3 course, would require development of appropriate equipment-specific display symbology such as the ASA-66 tactical data display control panel. This requirement could probably be handled equally effectively by video or computer graphics. If CAI is to be used in a tactical simulation mode, similar to the TACCO proficiency program (TAPP) embedded in the aircraft CP-901 computer, dynamic display of the appropriate symbology would be required. This could be handled better by interactive computer graphics system than by video.

4. Video/Photographic presentations. The primary area in which static video or photographic presentations would be required is for gram analysis practice in the SS 1/2 course. This could be accomplished by using either video or rear-projected microfiche images on a plasma display. There may also be equipment simulation applications in the other courses in which photographs or video images of equipment, controls, and aircraft interiors are desirable. Existing slide-tape programs could be converted to CAI format by using random-access video or microfiche systems.

Conversion of existing FE videotapes to a more interactive format, using either random-access videotape or videodisc, would be the primary application for realistic dynamic sequences. Video could also be used as the delivery medium for computer-generated graphics that are so complex that the computer system cannot generate the images in real-time. The computer images could then be recorded frame-by-frame on videotape to allow real-time playback on videotape or videodisc delivery systems.

5. Resolution. Looking at graphics requirements across courses, two levels of resolution would be required: the standard 512 by 512 and a higher resolution for at least the pilot course. Any computer-generated graphics system should at least be capable of the same resolution as the monitor used in the student terminal. This would be approximately 256 by 512 picture elements for a color television receiver, while standard graphics CRT or plasma displays offer resolution of 512 by 512 or 480 by 640 elements. Monochrome 512 by 512 resolution with computer graphics is sufficient for most applications.

The primary application area for high-resolution systems would be in the pilot course, where extremely complex schematics and diagrams must be adapted for interactive CAI. If a cost-effective higher-resolution terminal were implemented, it could also be used in the other courses to display more detailed graphics, such as control panel representations.

A variety of high-resolution monitors are also available. These are characterized either by the number of raster lines--typically 800, 1000, or 1100 lines--or the number of addressable picture elements--typically, 1024 by 1024, 2048 by 2048, and 4096 by 4096. Since high-resolution terminals are considerably more expensive than are standard resolution systems, it is extremely important to determine as precisely as possible the maximum resolution required for the more complex graphics. The lower end of high resolution displays would probably be sufficient.

Film media, such as random-access microfiche or transparent overlays on a color CRT, might be more cost effective than a high-resolution CRT with static and limited dynamic graphics. Tradeoffs must be made between hardware costs, media production costs, and the range of graphics applications to decide the most appropriate system for supporting high-resolution graphics.

Student Interaction Features

Since most of the applications involve simulation of equipment operations, touch input capabilities are required. The system should at least allow pointing to the display screen; a system such as a sonic digitizer, which allows off-screen pointing, would probably be preferable. With the on-screen point capability, a video, computer graphic, or rear-projected microfiche image of the control panel would have to be displayed on the student monitor. However, with an off-screen pointing system, printed or photographic representations of the control panel could be attached in appropriate positions around the display screen.

Other options for simulating equipment interaction involve an actual three-dimensional mockup of the panel, undoubtedly the most expensive alternative, or one or more general-purpose keypads could be used with appropriate stick-on key labels. A standard ASCII keyboard is required and, if instructional strategies, such as helps, were incorporated in the CAI system, custom keypads would probably also be desirable for heavily used instructional response features.

CAI SYSTEM EVALUATION

State-of-the-Art Technology

The continuing evolution in CAI systems is spurred by advances in computer technology, audiovisual media hardware, applied instructional theory, and computer programming systems. By the time a given CAI system has been designed and a prototype evaluated, many of its component parts may be obsolete, at least in the sense that cheaper, smaller, or more powerful components have become available since the initial design took place. However, CAI system vendors are frequently able to incorporate the latest advances in computer or media technology into their systems and still maintain compatibility with the original system design. Thus, older systems might remain competitive with newer designs that might have been inspired by the introduction of a new computer or media product. The optical videodisc is a good example of this. Although a dozen or more new videodisc-based CAI systems are now in various stages of development, most of the vendors of existing CAI systems have also added a videodisc interface to their systems so that the benefits of the new technology can be added to already proven systems.

To a large degree, the basic hardware components of many of the new CAI systems are remarkably similar--microcomputer-based, at least a basic computer-generated graphics capability, random-access videotape/videodisc interface, and touch input options. However, there are also major differences such as in the amount of random-access memory available, resolution of graphics display, processor speed, power and ease of using the graphics software, and the instructional strategies and authoring tools provided by the CAI software.

The remainder of this section describes four areas that represent important CAI capabilities--graphics displays, video displays and storage, student interaction, and processing and storage capability.

Graphics Displays

Most of the potential applications identified earlier are part-task simulations for procedural training that require relatively high-resolution computer graphics software and graphics display, as well as screen-pointing input devices. Since graphic display requirements are a critical factor in P-3 CAI applications, some of the different display alternatives and their associated tradeoffs are of interest. Graphics display considerations include video compatibility, resolution, and computer graphics software.

1. Video Capability. The first tradeoff to consider is whether a matrix-addressed or raster-scan display system should be used. The advantage of raster-scan, which is used in standard National Television System Committee (NTSC) television systems, is that it can be used for both video and computer graphics. Many of the systems now being designed incorporate a genlock sync system that allows computer graphics to be placed directly on images from a video source. The disadvantage of raster-scan is that it requires a fairly large amount of dedicated display memory to hold a bit-map of each individually-addressable picture element. However, this is becoming less of a disadvantage, because semiconductor memory costs are continually declining.

If an NTSC-compatible format is used, resolution is limited to that of a standard television image. In many cases, this is inadequate for detailed instructional graphics. Available non-NTSC raster formats include the RS-170 red-green-blue (RGB) format, which provides crisper graphics and better color, and a number of high resolution formats such as 800-and 1,000-line systems. These are considerably more expensive, although costs should decline over the next few years. A high-resolution raster format is incompatible with NTSC video. Efforts are underway to develop an interface to allow the lower-resolution NTSC signal to be displayed on high-resolution screens. However, two display screens are currently required to use both NTSC video and a high-resolution format.

The matrix-addressed display is typified by the flat panel plasma displays used by systems such as the General Electric training system (GETS), programmed logic for automatic teaching operation (PLATO), the plasma terminal system used by the National Library of Medicine, and Regency-Carroll's System 1. Most of the other non-CRT flat panel systems now under development also use the matrix approach, in which each point on the screen is addressed directly through separate electronic elements. Although the plasma displays are monochrome and incompatible with video signals, slides and microfiche can be rear-projected on the display to provide realistic color static graphics when needed. The major advantage of the plasma terminal over the raster-scan device is that its resolution of 512 by 512 elements is higher than the 512 by 256 available for computer graphics and is somewhat less for video on a standard color television monitor. The plasma display also flickers less.

There also are a number of different random-scan or vector systems in which the electron beam is moved directly to specified X- and Y-coordinates rather than being swept through a raster pattern. This approach includes both refresh and storage tube systems and is highly efficient for rapid line drawing, but it is incompatible with a video system.

2. Resolution. The resolution of a color NTSC raster system is approximately 240 by 320 elements, while most inexpensive or moderately priced CAI and home computer systems provide a 256 by 256 display matrix. The regular video image provides a great deal with which to work. For example, videodisc material showed that a relatively simple keyboard with 16 keys could be adequately displayed on a video monitor. However, it was

impossible to display the entire keyboard and associated display at that level of resolution. On the other hand, the PLATO CAI system, which uses a 512 by 512 plasma display, was able to display the entire system quite well.

It is possible that even a 512 by 512 plasma display matrix might not be adequate for some of the more complex graphics related to the propeller, electrical, and hydraulic systems. The range of P-3 CAI graphics requirements should be examined quite closely against the capabilities of both 512 by 512 and higher resolution display systems to determine the ideal level of resolution.

3. Computer Graphics Software. Although great strides are being made in computer graphics research on a variety of levels, most of this work has focused on applications other than instruction. Thus, no one has attempted to integrate the existing number of interesting general-purpose graphics systems into an overall instructional package. A hierarchy of computer graphics capabilities against which various CAI systems may be evaluated is listed below:

a. Digitizers. Many graphics systems incorporate some kind of device that allows manually-developed graphics to be digitized and stored in computer memory for display. These can be scanning devices, tablets for direct picture inputs, or a variety of cursors that allow input of endpoints for line drawings. This approach relies on conventional manual techniques to develop original graphics but facilitates editing.

b. Graphic cells. This approach is used by time shared interactive computer controlled instructional television (TICCIT) and the initial versions of GETS. The screen is divided into a number of graphic cells composed of a matrix of addressable picture elements. Various patterns can be written into each cell to compose symbols, alphabets, markers, or graphic subelements that can be arranged to make larger line graphics. The last application, however, is both time consuming and limited in the variety of pictures that can be developed.

c. "Turtle" graphics. This approach is used in the UCSD Pascal software package and several other graphics systems. Keyboard inputs of coordinates on line lengths cause a line to be drawn from an origin to the specified coordinates, while angle and line length inputs will cause a new line to be drawn in that direction. Some fairly complex two-dimensional drawings can be made in this manner, but the process is time-consuming.

d. Line, arc, and circle drawing through input of endpoints. A number of systems require only the input of two or more points to define a two-dimensional figure such as a line or circle. This can be accomplished through keyboard input of coordinates or use of a screen cursor control. Some systems also support Bezier curves. For example, a curve will be drawn that is defined by "averaging" the position of an origin point plus three other points not on the curve. The enhanced version of GETS supports this type of vector graphics.

e. Object-oriented systems. In these systems, the basic units are various two- and three-dimensional polyhedra that can be used to compose larger complex objects. These primitives can be scaled to any dimension, rotated, translated to any position on the screen, etc. This approach is much more powerful than input of points or lines but incurs more hardware and software costs to support the various functions available. The three-dimensional system is currently limited to very expensive mainframe-oriented systems.

f. Three-dimensional shaded color graphics. A great deal of research is being conducted to develop sophisticated techniques for producing highly realistic shaded color graphics. These applications, which require a great deal of memory and processing power, are currently limited to expensive systems for animation, commercial artwork, advanced flight simulators, etc. As hardware costs continue to drop, it will eventually be possible to incorporate these capabilities into relatively inexpensive systems.

The Association for Computing Machinery's Special Interest Group for Graphics (SIGGRAPH) has been working toward standardization of computer graphic software over the last several years. The SIGGRAPH core standard, which is commercially available in FORTRAN and "C" languages, has been implemented primarily on mainframe and minicomputers, although the new generation of 16-bit microcomputers should be able to handle at least some of it. The core supports translation, rotation, and scaling of objects; windowing; zooming; a variety of input and output devices; and a number of other useful graphic features. As the core develops into an ANSI standard over the next 2 or 3 years, it should be implemented in a variety of programming languages and as part of larger instructional systems. A great deal of effort is now being expended to develop extensions of the core for raster graphics systems so that shaded, textured graphics will eventually be part of the standardization effort.

To develop instructional programs, an ideal graphics system should be both powerful and easy to use. The best system is also one that has been custom-tailored for a specific application. Various computer-aided design systems. which have been developed for engineers and draftsmen, feature elaborate menu structures in which libraries of commonly-used graphics are stored in memory and available on a single command enabling the designer or artist to develop complex graphics by applying previously developed tools chosen from the menu. There are a number of these systems available for flowcharting, schematics, and program evaluation and review technique (PERT) charts. It should be possible to develop a menu-oriented system for common equipment panel elements, tactical symbols, and other graphics using any general-purpose picture-building graphics package. Some graphics would have only a single use and would be developed by an artist-programmer using the basic programming commands in the software. The primary point is that the basic graphics package should offer as many features as possible to aid the artist in developing pictures. Beyond that, frequently used graphics should be organized in menu structures so that anyone can build a relatively complex display without detailed interaction with the programming language. This consideration is especially relevant for a P-3 CAI system since the goal is in-house development and support.

Video Displays and Storage

The development of interactive videotape and videodisc systems has spurred a great deal of hardware and software development over the last 2 years. The main focus has been to develop videodisc controller interfaces for various small computer systems. These include simple controllers that send commands from the microcomputer to videodisc player microprocessor controllers, modifications to videodisc player electronics to communicate frame number locations back to the microcomputer, modifications to consumer videodisc players to allow control by external computers, and genlock circuitry to allow overlay of computer-generated graphics on the video image stored on disc or tape.

The optical videodisc has several outstanding advantages over other audiovisual media, such as the ability to store approximately 50,000 addressable single frames and its extremely low cost to duplicate in quantities. It would be possible to store the entire P-3 curriculum on a single disc. However, curriculum revisions would eventually require a new videodisc. A small number of copies would result in much higher per disc costs than applications requiring hundreds or thousands of copies.

Although videodiscs can store large amounts of information, there are still unanswered questions about the effectiveness of the video as the delivery medium of the entire range of instructional materials. Some of the issues that must be resolved before large-scale implementation in military training are effectiveness of limited resolution, the effects of video flicker on students spending a great deal of time reading the screen, media production techniques, disc quality control, player reliability, and access to mastering/replication facilities. A CAI system that features both computer-generated graphics and videodisc would eliminate some of these problems, but the design of effective instruction requires close attention to the tradeoffs involved in delivering materials in either of the two modes.

Student Interaction

A number of options are available for simulating inputs on the various P-3 equipment panels. The major issue is cost, which can be assumed to increase as the fidelity of the options listed below increases.

1. Using a CRT or plasma panel with a light pen, cursor, or touch sensitive panel. This approach was used in the TICCIT simulation developed for P-3 demonstration purposes.

2. Using a touch sensitive system that will also allow off-screen touch points. This approach has been used by GETS for TRIDENT training and by the Generalized Maintenance Training System (GMTS) for electronic maintenance simulations.

3. Interfacing the CRT/plasma display to three-dimensional mockups of buttons, switches, or other control panel inputs. Both TICCIT and GETS are developing such interfaces.

4. Interfacing an entire operational control panel to a microcomputer system to simulate the inputs from various P-3 computers, operational equipment, and crew stations.

Processing and Storage Capability

Many of the new microprocessor-based CAI systems provide greater stand-alone computing power and portability than do previous mainframe and minicomputer-based systems. The latest generation of single-board microcomputers will allow even greater power and/or smaller size to be incorporated into future CAI hardware. The new 16- and 32-bit microprocessors offer as much and, in some cases, more processing power than do most mid-range minicomputers. In particular, the extended direct addressing capacity--from 256K to 16M bytes vs. 65K for the standard minicomputer--allows greater sophistication in graphics software, higher display resolution, and more color capability.

Most of today's smaller CAI systems use standard 8-bit microprocessors to support only limited graphics resolution and programming capabilities. The National Library of Medicine's Plasma Terminal System uses two 8-bit microprocessors to allow sufficient graphics and processing power. The University of Utah CAI system, which uses microprocessors built by the Terak Corporation, is based on a 16-bit LSI-11/2, but direct addressing to 65K constrains the system to medium resolution, a monochrome display, and relatively slow write-times for more complex graphics. The GETS system is somewhat unique among stand-alone CAI systems in that it actually contains seven different custom processors or large function modules (LFMs) to handle specific processing and display requirements.

One of the most important CAI research and development goals should be to design a system that fully uses the capabilities of the new generation of 16-bit microprocessors. A great deal of activity will continue to develop smaller systems at minimum costs with limited graphics and processing power, but more demanding CAI applications, such as military technical training, require more sophisticated software for effective graphics and simulation. Most of today's commercial CAI systems will probably incorporate the more powerful stand-alone processors now available, but entirely new CAI approaches may be developed using the latest technology.

State-of-the-Art Options

The state-of-the-art CAI options for P-3 aircrew training fall into two categories. One covers commercial CAI systems that have been implemented and evaluated in other military training settings, while the other includes modifications to existing P-3 training resources to develop new CAI capabilities. The options in both categories have advantages and disadvantages, which are discussed below:

Commercial CAI Systems

Only two systems, GETS and TICCIT, were found to have sufficient capabilities to support the potential CAI applications identified in the P-3 curriculum. TICCIT and GETS do not use technologies that are inherently superior to those of the other systems, but they do have organizations that have engineered workable solutions to some of the key problems involved in supporting the P-3 CAI applications. Both TICCIT and GETS have been enhanced to support military training simulation requirements. Although some of the other systems have individual features that are superior to TICCIT and/or GETS, they cannot support many of the applications.

The difference is one of scope--both in system design and support. Many of the other systems have been designed with minimum cost, rather than system capability, as the primary consideration. Also, many of the systems have been designed by small groups in academic institutions attempting to use innovative technology, such as the videodisc, for their own specific institutional needs. The Hazeltine and General Electric Ordnance Systems, the vendors for TICCIT and GETS respectively, have sizable staffs devoted to system maintenance and development of software, hardware, user technologies, and instructional applications.

GETS. GETS uses a monochrome plasma terminal with 512 by 512 resolution as its primary display medium. A videodisc interface has also been developed to allow GETS graphics to be overlaid on videodisc pictorals using a standard NTSC television monitor. Student inputs may be made from a standard keyboard or a sonic pen that has recently been enhanced to allow off-screen touch points. This permits representations of equipment panels to be placed on the screen to simulate the procedures and operations for a wide variety of aircraft controls. A built-in random-access slide projector allows 35mm color slides to be rear-projected on the plasma screen. A number of custom-developed LFMs handle response processing and display functions and a 2.4 megabyte floppy disc supplies program storage for the system. The LFMs are divided into four basic subsystems: input processing, program execution, mass data transfer, and output processing. An author cart, a unit that plugs into the standard student station, provides a printer for hard copy and an additional floppy disc unit to duplicate lesson discs.

The GETS graphics software provides both graphic cells and vector graphics capabilities. The vector software allows lines, arcs, and circles to be defined by input of endpoints. The software also allows scaling and translation of images previously defined. This software was used in the simulation of the TRIDENT Submarine Standard Information Display Console OJ-326 ((V3)/UYK) and several other equipment simulations for operator training, which are as complex as the simulations needed for P-3 training.

GETS lessons can be written at several levels, including the on-line authoring system (OLAS), which contains (1) various interactive authoring procedure programs, (2) the string problem oriented machine language (SPOML), which is a terse APL-like high-level language designed for fast execution, (3) the computer-based instruction language (CBIL), which is a more comfortable FORTRAN-like language directly translated into SPOML before processing, and (4) the GETS primitives, which are at machine level for detailed interaction with the processing system.

OLAS provides an interactive lesson-authoring facility to generate standardized lesson segments organized as follows: (1) introduction, (2) description, (3) interrogation, (4) exercise, and (5) summary. The author can select from a variety of standard CAI structures, such as linear programmed learning, multiple choice, and various question/answer sets using text and graphics. Procedures are also provided for developing various support data items such as alphabets, symbols, pictures, touch points, and appendices composed of common SPOML program sequences for use at appropriate points in the lesson. All OLAS lesson segments are automatically translated by the system into corresponding SPOML code. The SPOML and CBIL languages are used to develop simulation exercises and other interactions not covered in the standard OLAS structures. SPOML is generally used in an on-line mode, while CBIL is designed for off-line program development.

TICCIT. TICCIT is a minicomputer-based multiterminal system that can support up to 128 terminals using a Data General Nova 4X minicomputer. A smaller stand-alone cluster version that can support from 1 to 16 terminals is under development and will be ready in time to be considered for the P-3 program. The display terminal is a modified Sony 12-inch television monitor, which can display either NTSC video or computer-generated text and graphics. Graphics resolution is 512 by 256, while character resolution is 17 rows by 43 columns of characters composed of a 10 by 12 dot matrix. The keyboard is composed of three keypad sections--a standard typewriter section, an editing and cursor control section, and a learner-control section structured around TICCIT's "rule, example, practice" instructional method. A light pen is also provided for direct touch inputs. Student progress and test performance history are monitored by the TICCIT management system, which provides prescriptions on how the student should proceed.

TICCIT provides several levels of lesson authoring and programming software. The standard authoring procedure for TICCIT, called authoring procedures for TICCIT (APT), is organized around a rule-example-practice-help structure similar to that presently used in the P-3 curriculum. The TICCIT authoring language (TAL) allows for development of other instructional strategies, including simulation programs. Other programming facilities include Data General's real-time disk operating system (RDOS), a text editor, an ALGOL compiler, a macro assembler, a library file editor, and a relocatable loader.

Among the system enhancements currently under development are a videodisc interface, a high-resolution color monitor with 1000 by 512 resolution, and a three-dimensional interface to allow the displays to interact with mockups of control panels using real knobs, switches, buttons, etc. Hazeltine has also demonstrated using a large 25-inch color monitor in conjunction with transparent overlays to provide high-resolution dynamic graphics. This approach would provide a fairly inexpensive way to meet dynamic graphics requirements for the propeller, hydraulic, electrical, and fuel systems in the pilot course.

Comparison of TICCIT and GETS. It is difficult to identify any outstanding advantages or disadvantages when comparing GETS and TICCIT. Table 8 provides summary of the features for each system. As shown, both systems provide on-line authoring capabilities to allow nonprogrammer authors to develop "standard" CAI instruction involving rule or content descriptions, helps, practice example, and testing. Both systems provide various levels of access to the system to allow skilled programmer authors to develop complex simulation routines. Both systems also provide a basic graphic cells approach to support development of such items as type fonts, alphabets, symbols, highlighting, picture elements. At this point, the GETS vector graphics system offers a software advantage, although this level of capability is fairly common to a number of standard graphics systems and could undoubtedly be implemented on TICCIT given appropriate specifications. The built-in programming possibilities for each system should be sufficient to allow enhancements beyond the current graphics software.

Each system currently shows both strengths and weaknesses in display hardware. The standard GETS 512 by 512 plasma panel provides higher resolution, less flicker, and greater viewing ease than does the 512 by 256 Sony television monitor used by TICCIT. On the other hand, TICCIT provides a color capability in both its small- and large-screen displays. The use of high-resolution transparencies in conjunction with the large-screen display offers an attractive solution to problems of using dynamic graphics to teach complex system operation. Both systems can be used with videodiscs and in two-screen modes. Although the GETS videodisc interface has already been demonstrated, the engineering effort involved in developing a genlock graphics overlay interface is not particularly difficult and a variety of such interfaces should be available in the near future. TICCIT also has a high-resolution 1000 by 512 color monitor under development but this uses a fairly straightforward technology that GETS or other sources could also provide if required.

The GETS sonic pen represents an advantage over the TICCIT light pen since off-screen touch points can be programmed to simulate a wide variety of P-3 equipment panels. While this capability can also be provided using computer graphics and a dual screen system, the GETS approach permits available paper representations of P-3 panels to be used in interactive simulations. The GETS rear-projection capability also allows the use of photographic representations of actual equipment. The resolution provided by 35mm slides far exceeds that of standard television monitors for displaying complex equipment panels.

TICCIT, on the other hand, has an advantage with its large-screen monitor/transparency approach for developing dynamic graphic representations of complex system flow and function. For example, a large transparency, developed from NATOPS diagrams, can be positioned over the CRT face and the paths through the schematic or diagram can be backlit with various colors to allow a dynamic illustration of system operation. It is entirely likely that either company could support custom system enhancements to provide identical capabilities.

Table 8

Comparison of GETS and TICCIT System Characteristics

System Characteristics	GETS	TICCIT
Display characteristics:		
•Dual screen option	x	x
•Screen types	Plasma/color CRT	Color CRT
•Resolution	512 x 512/512 x 256	512 x 256/ 1,000 x 512
•Refresh rate (flicker)	None/30Hz video	30Hz video
Videodisc/videotape interface	x	Planned
•Controller only	--	--
•Text overlay	--	--
•Graphics overlay	x	--
Graphics software:		
•Digitizer	x	x
•Graphics cells	x	x
•2-D line drawing	x	--
•3-D shaded/textured	--	--
•Scaling/translation	x	--
Text features:		
•Number of standard type fonts	Several	14
•Highlighting	x	x
•User-defined fonts and symbols	x	x
Input devices:		
•ASCII keyboard	x	x
•Cursor control	x	x
•Instructional function keypad	x	x
•Touch input	Sonic pen	Light pen
off-screen touch points	x	--
•Interface to 3-D control panel	x	x
Hard copy available	x	x
Instructional programming software:		
•High-level languages	SPOML/CBIL	TAL/ALGOL
Transportable	--	--
Nontransportable	x	x
•Macro assembler	x	x
•Machine code access	x	x
•Drill of practice	x	x
•True/false	x	x
•Multiple-choice	x	x
•String matching	x	x
•Calculation program	x	x
•Simulation capabilities	x	x
•Student response history and other record keeping	x	x
•On-line/off-line authoring aids	x	x

System life cycle costs could prove to be the major discriminating factor between the systems. However, estimates are precise enough to discriminate between lesson development costs and might be difficult to develop since no baseline data are available to compare authoring costs between CAI systems. Both TICCIT and GETS have demonstrated that they can support complex simulations, but there is no readily available data on how much effort was required to develop these. System hardware costing also requires close attention to the exact configuration required to meet P-3 potential CAI applications.

Use of Existing Resources

Based on interviews with VP-31 personnel, three options were investigated for possible modifications to existing resources to provide a CAI capability for P-3 aircrew training.

1. Suitcase Trainers. Personnel from the Naval Weapons Center (NWC), China Lake, California have discussed the possibility of interfacing actual control panels with microcomputer systems to create highly-portable, high-fidelity suitcase trainers. As detailed proposals have not been prepared, it is impossible to discuss the CAI capabilities and role these trainers might play in the curriculum. Although this approach could use equipment or spares in the training inventory, the primary consideration is development cost. Software development would cost less if effective simulations could be provided on a general purpose CAI system than if suitcase trainers had to be developed for each major piece of equipment. More information, in terms of capabilities and development costs, is required to determine whether this is a feasible option for P-3 aircrew training.

2. Embedded Training. One option to enhance P-3 aircrew training is the development of embedded training programs similar to the TACCO proficiency program (TAPP), which was developed by the Naval Air Development Center (NADC) to train tactical procedures on TACCO station equipment. It might be possible to develop similar programs for some of the other crew positions and link the stations together for crew training scenarios. NADC estimated that TAPP, which required direct modifications to the CP-901 operating system, involved approximately 7,500 man-hours of programming. Embedded training program development for other positions would be feasible if NADC were to perform the work. However, further study is required to determine what role these embedded programs would play in the overall curriculum.

The advantages of using real equipment onboard the aircraft to teach procedures and provide additional practice are obvious. With the increasing costs of fuel, training programs that save airborne time and make efficient use of the aircraft on the ground appear to be attractive options. The disadvantages associated with this approach include the large programming effort involved and potential for aircraft availability problems.

3. Aviation Training Support System (ATSS). There are indications that ATSS, which is being installed in the P-3 instructional system to support such curriculum management functions as scheduling and test scoring, might be upgraded to provide CAI capabilities by adding a 256 by 256 graphics board to the existing monochrome alphanumeric terminals and a touch panel or light pen for touch inputs. Development of a microcomputer/videodisc system has also been mentioned since a suitable videodisc interface to the PDP 11 might be available within the time frame discussed for CAI implementation. These modifications would support some of the potential CAI applications described earlier, but additional hardware enhancements would be required to satisfy the resolution and dual screen requirements that were identified in the study. ATSS would also have to be augmented with a large- or high-resolution screen and/or an off-screen touch print capability.

Many of the questions related to enhancing ATSS to provide a CAI capability concern instructional software and graphics software. The Digital Equipment Corporation (DEC) "DECAL" CAI authoring language could supply some of the basic branching functions required for text-oriented tutorials, practice, and tests, but most of the CAI applications require much more sophisticated graphics and interactive simulation capabilities.

One of the first steps required for CAI development would be to determine whether any existing software packages could be used and if they run under one of the DEC-compatible operating systems. The current ATSS software is written in Basic Plus and runs on the DEC RSTS operating system. It may be necessary to purchase programming language compilers such as Fortran, Pascal, or "C" (which is available as part of the UNIX operating system).

Implementations of the SIGGRAPH core graphics standard currently available on PDP 11 systems include:

1. DIGRAF from the University of Colorado, which requires ANSI 66 Fortran.

2. A UNIX C implementation, which was originally developed within DoD and is now available from a commercial vendor in New York.

3. A Fortran implementation, which is available from the Systems Design Group in Los Angeles.

In addition, Pascal implementations will probably be available in the future. Any of these packages would provide a powerful general-purpose picture-building language to develop software-oriented applications to meet P-3 training requirements.

Consideration should be given to the design of a user interface to provide maximum support to a broad range of users with different levels of expertise and interest in programming details. The typical user should be shielded as much as possible from the details of program coding through the development of menu structures and a library of P-3 specific graphic objects. System designers should also consider the kinds of input devices (e.g., special function keys, joysticks, touch panels) to be included in the authoring and delivery systems.

Another important factor in system design is how much intelligence should be included in the student terminals to handle the processing of display and instructional program functions. Ideally, the microcomputer in the terminal should be able to process a variety of routines, input/output devices, instructional functions, and simple graphics in a stand-alone mode, while more complex graphics and equipment simulations may require additional data base storage and processing from the PDP 11/70. A number of stand-alone CAI systems currently use the LSI-11/2, and the recently introduced LSI-11/23 allows even more functions to be handled in a stand-alone mode. It is difficult to say how easily existing LSI-11-based instructional graphics and hardware/software systems could be upgraded to operate as part of a distributed processing system like ATSS or whether an entirely new software environment would have to be designed to optimize tradeoffs between terminal and CPU functions.

The development of a new CAI system using ATSS is not a trivial task. The overall costs involved in developing such a system would be much higher than acquisition of an existing system from an established vendor. To develop a new CAI system on the PDP 11 would require at least 2 years, even if existing software packages could be used to provide some of the necessary system functions. To develop and implement an integrated CAI system would require a substantial effort. The availability of continuing software support, maintenance, and system enhancements should also be considered in evaluating this option. One of the advantages of a commercial CAI system is the fact that a large organization has made a commitment to support the system and develop enhancements in response to new applications.

Future Development of CAI Systems

With such diverse computer and display system components becoming available, CAI research and development could proceed in many directions. However, several of these areas already receiving a great deal of attention are:

1. Intelligent videodisc systems in which overlay of computer-generated text and graphics on video images is possible.

2. Low-cost low-resolution CAI systems, exemplified by educational applications for various home computers.

3. Medium-resolution graphics/CAI systems, such as the University of Utah's Terak/Pascal system.

Aside from these areas, a number of state-of-the-art components might be integrated into a high-capability system that might eventually cost from $10K to $20K for a stand-alone smart terminal. Given the possible long lead-time for acquisition of CAI in the P-3 program, some of these elements could be considered if any developmental work is attempted.

One design goal might center on a single-board 16-bit microcomputer system that could support relatively sophisticated graphics and instructional software and form the core of a highly portable expandable CAI system. Some of the components of such a system might be as follows:

1. Any of several new 16/32-bit microprocessor CPUs (e.g. 8086, Z8000, LSI-11/23, N6800), which are capable of starting from 256K to 16M bytes, should be included.

2. A random-access memory (RAM) board composed of the new 64K chips, preferably with extra slots for later system expansion to support enhanced software systems, should be considered.

3. A color graphics terminal with at least 512 by 512 or 480 by 640 resolution should be included. This could involve (a) an existing system, such as the AED 512 now selling in the $8K to $10K range, (b) an advanced graphics terminal design using a conventional CRT, or (c) a terminal developed from new display technologies such as liquid crystal, electrochromic, or flat CRTs. A flat panel is not vital to the system if the appropriate technology is not available, but it would definitely be desirable in terms of high portability.

4. Alternatively, a high resolution display, either color or monochrome, would be highly desirable if the associated costs could be reduced. An 800-to 1,000-line raster system would probably be the most appropriate target, especially if an interface could be developed to allow standard NTSC video to be displayed on the system along with higher-resolution graphics.

5. Auxiliary memory devices (e.g. bubble memories or mini-floppy disc systems), which would lend themselves to an overall goal of high system portability, should be considered.

6. Powerful graphics software, such as implementation of as much of the SIGGRAPH core standard as cost goals will support, should be included.

7. The use of ADA, the DoD-developed state-of-the-art programming language, would be desirable if a compiler can be developed for the target CPU without an inordinate amount of effort. Consideration could also be given to other languages, including one used in artificial intelligence research. Consideration could also be given to developing a hardware implementation of a compiler/interpreter, like Pascal.

8. A sonic pen, which would allow use of off-screen touch points, should be included.

9. The following interfaces should also be included: (a) RS-232 serial asynchronous interface, (b) IEEE-488 parallel interface to allow connection to three-dimensional mockups and other instrumentation, and (c) videodisc controller interface with genlock sync to allow overlay of computer-generated material on video images.

DISCUSSION AND CONCLUSIONS

Based upon interviews with VP-31 personnel, 59.5 hours of instruction were identified for potential CAI application from a sample of courses for five aircrew positions: pilot, FE, BNFO, CSS 1/2, and CSS 3. Although these CAI hours are related to specific problem areas in the curriculum that require improvement, they can be considered representative of other CAI applications in the training program. By identifying priority areas for initial implementation, CAI could be gradually introduced into the curriculum without overstraining existing resources. However, once the initial capability is available, a number of applications could be developed.

A two-screen display system with color, dynamic graphics, and good resolution would be highly desirable for implementing the kinds of equipment simulations discussed for the pilot, NFO, and SS 3 courses.

Evaluation of the CAI media characteristic requirements indicated that two commercial CAI systems, TICCIT and GETS, can functionally satisfy the identified training requirements.

An initial configuration of six student stations each at VP-30 and VP-31 was calculated on the basis of the 59.5 CAI hours identified in the study, planned student loading, and contingency factors such as downtime, group scheduling, authoring. Such a baseline figure can be used for facilities and support planning, budgeting, and cost comparisons of alternative CAI systems. However, beyond the initial system configuration calculations, other factors, such as the potential for growth, could be considered if the CAI system is to be selected on the basis of costs. Based on comments by VP-31 personnel and course developers, estimates for potential CAI utilization in the P-3 curriculum range from 30 to 60 percent. This range does not include the possibility, which has been suggested by some aviation training personnel, that all or most of the print media could be eliminated by CAI.

The number of student terminal hours and student stations required impacts the selection of a CAI system on the basis of costs. Systems designed for many terminals are often less cost effective than stand-alone terminal systems when only a few terminals are required. The opposite can be true as the number of terminals increases. The exact figures--identifying which system is more cost effective than another CAI system or a nonCAI system alternative--can only be arrived at through life-cycle costing.[1]

RECOMMENDATIONS

1. Formal evaluation data on the effectiveness of the P-3 Instructional System implemented at VP-30 and VP-31 should be collected and analyzed to identify revisions. Areas to be investigated should include, but not be limited to:

   a. Adequacy of the testing procedures,

   b. Scheduling and sequencing of device sessions to ensure efficient utilization of trainers and aircraft.

   c. Use of weapon system trainers for part-task training,

   d. Use of existing random-access videotape capabilities,

   e. Introduction of additional seminars and revised workbooks in problem areas in the curriculum.

2. As the evaluation data become available, decisions should be made by users and sponsors concerning the implementation of CAI to improve the effectiveness of the P-3 Instructional System. If CAI appears to be warranted, then VP-30 and VP-31 should investigate these options further:

   a. The requirements and costs to develop and support additional embedded training programs on the CP-901 computer should be pursued with the appropriate personnel at Naval Air Development Center. Although this option appears to be viable, detailed discussions should be conducted to determine the full range of implications and tradeoffs associated with this CAI option.

   b. The requirements cost, scope, and feasibility of enhancing ATSS to include a CAI capability should be pursued with NWC China Lake. Specific enhancements, such as an ATSS link with the random-access videotape equipment in the learning center wet carrels, should be defined. Development time and costs, personnel requirements and availability, systems integration responsibility, logistic and operating support requirements are some of the issues that should be addressed in detail.

   c. In addition, the logistic and operating support requirements for commercial CAI systems should be examined. The practical implications for including CAI in the media mix must be identified in terms of manpower and facilities.

3. Life-cycle costs should be the basis for selecting the alternative to improve the P-3 instructional system, if it is decided to implement CAI.

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[1]The considerations and methodology for CAI system life cycle costing are discussed in the appendix.

APPENDIX

CAI SYSTEM LIFE-CYCLE COSTING

CAI SYSTEM LIFE-CYCLE COSTING

There are two approaches for determining the costs and benefits associated with including CAI in the P-3 media mix. In both approaches the P-3 instructional system support requirements without CAI (the status quo) are compared with the development and support of instructional materials on one of several CAI system capabilities (CAI alternative). However, either the costs or the benefits must be fixed at some level to permit meaningful comparisons between the status quo and the CAI alternative over the life cycle.

The key difference in the approaches is related to the objective for conducting the life-cycle cost analysis. If the objective of the analysis is to maximize the training effectiveness for a given funding level, then the costs are fixed at a maximum level. If the objective of the analysis is to achieve a certain level of training effectiveness with the least cost, then the benefits are fixed at a measurable level.

The fixed costs/variable benefits approach would provide life-cycle cost data to evaluate the potential for CAI utilization in P-3 aircrew training. It would provide CAI cost data for program planning and budgeting decisions, as well as training effectiveness information and logistical support data to justify the decision to implement CAI. The variable cost/fixed benefits approach would provide life-cycle cost data to evaluate the potential of CAI to improve the level of P-3 aircrew training. It would provide cost and logistical support data for alternative methods to improve identified training problems.

In both approaches, the CAI alternative that best satisfies the four system selection criteria, listed below, would be costed against the status quo:

1. Capable of delivering P-3 instructional materials.
2. Capable of accepting curriculum revisions.
3. Capable of generating data to manage the training program.
4. Supportable by the Navy.

Although the life-cycle cost components to be included in the model and cost estimating techniques remain essentially the same, the cost-modeling exercise, parameters, and assumptions for the two approaches differ.

Fixed Cost/Variable Benefits

The fixed costs/variable benefits approach assumes that a substantial number (approximately 30% to 60%), of the learning center objectives currently presented by workbooks, videotapes/slide-tapes, or seminars would be implemented on CAI. The costs and benefits associated with the follow-on support requirements documented in the P-3 instructional system management plan (status quo) would be compared with the costs and benefits associated with reduced follow-on support requirements and the implementation of CAI (CAI alternative) over the curriculum life-cycle. The parameters for this approach are depicted below:

Status Quo	CAI Alternative
ISD Maintenance and support costs	CAI implementation costs (development & maintenance) and ISD maintenance and support costs at reduced level

A tentative work breakdown structure (WBS) framework for the cost model is provided below:

Delivery System Costs

1.0 Hardware/software acquisition (nonrecurring) (includes costs of purchasing systems to specifications).

2.0 Hardware/software support (recurring) (includes costs for operation and maintenance).

3.0 Duplication/distribution (nonrecurring) (includes costs for preparing and duplicating the initial validated instruction).

Training Materials Costs

4.0 Development (nonrecurring) (includes costs for initial development of media from objectives and specifications).

5.0 Revision (recurring) (includes costs for development, duplication, and distribution of updates and corrections to training materials).

Management Costs

6.0 Administrative support (nonrecurring and recurring) (implies generation of data to manage and evaluate training program components).

7.0 Instructional support (nonrecurring and recurring) (implies generation of management data to guide the student through the instructional process).

The three major cost categories shown are related to the four systems selection criteria. The management costs category is related to the system capability for generating data necessary to manage the training program. The cost elements associated with both the delivery system and the instructional materials categories would provide information for the following criteria:

1. Capable of delivering P-3 instructional materials.
2. Capable of accepting curriculum revisions.
3. Supportable by the Navy.

Effectiveness measures that relate to the system criteria, rather than benefits statements per se, would be developed. The effectiveness measures would be both quantitative and qualitative in nature. The quantifiable measures may be directly related to cost and would be considered in refining the WBS cost model. The qualitative measures would serve as moderators and provide additional information for Navy decision makers. Essentially. the effectiveness measures identify sensitive cost variables and define the tradeoffs that exist within and between the alternatives.

Fixed Benefits/Variable Costs

The fixed benefits/variable costs approach assumes that a limited number of learning center objectives--those related to specific training problems requiring improvement--would be implemented on CAI. The comparision would be between a variety of alternatives, such as CAI in several forms, the introduction of ATSS, changes in testing, adding seminars with and without mediation, and resequencing instruction. Figure A-1 graphically depicts the parameters for this approach.

Training Problems to Accomplish Level	Status Quo				CAI Alternative			
	Workbook	Instructor	Device Session	Miscellaneous	GETS	TICCIT	Conceptual	Miscellaneous
1	x	--	--	--	--	--	--	x
2	--	x	--	--	--	x	--	--
↓								
n								

Figure A-1. Fixed benefits/variable costs approach.

This type of cost analysis requires a more complex modeling and costing exercise. Each training problem requires a separate analysis. The most suitable option for each alternative (status quo and CAI) would be identified, and the specific costs associated with that option for that problem would be determined and estimated. The cost components displayed previously might be relevant or it might be necessary to develop a subset of cost components for a specific training problem.

The benefits would be defined in terms of solving the training problems to achieve the improved level of training. Guidelines for identifying training problems and establishing a measure for training improvement would be developed to determine whether the objectives for conducting the analysis can be satisfied by implementing one or a mix of alternatives.

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