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OBSERVATIONS ON THE USE AND EVALUATION OF ECII-LP SIMULATORS FO--ETC(U)
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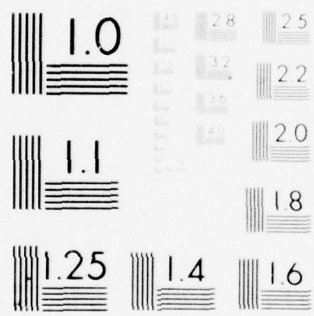

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CNETS REPORT 2-76

OBSERVATIONS ON

THE USE AND EVALUATION OF

ECII-LP SIMULATORS FOR AVIATION TRAINING

OCTOBER 1976

CNETS REPORT 2-76

OBSERVATIONS ON THE USE AND EVALUATION OF ECII-LP SIMULATORS FOR AVIATION TRAINING

(CNETS Field Task Assignment No. 60082)

PREPARED FOR
THE CHIEF OF NAVAL EDUCATION AND TRAINING SUPPORT

BY

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DEPARTMENT OF THE NAVY
CHIEF OF NAVAL EDUCATION AND TRAINING SUPPORT
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1. CNETS Study Report 2-76, "Observations on the Use and Evaluation of ECII-LP Simulators for Aviation Training" is promulgated for information.

2. The conclusions and recommendations contained in the report are those of the writer and are not necessarily those of the Chief of Naval Education and Training Support.

3. This publication has been reviewed under the provisions of SECNAVINST 5600.16 and is approved.

Wayne Hughes Jr.
WAYNE P. HUGHES, JR.

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1.0 SUMMARY. An evaluation of the training effectiveness of ECII-LP simulators was undertaken using the participant-observer method. Comparisons were made between two aviation courses--pilot FAM which used the ECII-LPs to familiarize student pilots and instructor pilots with the T-2C aircraft, and NFO FAM which used transparencies, study guides, MTUs, and chalk boards to present familiarization training to NFO students who were transitioning to the TA-4 aircraft. Interviews, student questions, and a review of final test scores showed that the two courses were probably equally effective in meeting the training objectives if allowances are made for differences in student aptitudes and skills, previous aviation experience, and length of the training period. The observations found, however, that the courses also provided training in basic cockpit procedures although the final tests did not emphasize these objectives nor were the ECII-LPs being used effectively for this type of training. Although the ECII-LPs were highly mobile and presented training information in a well organized fashion, the rear projection visual system of the simulator was found to be inadequate, and panel replacement was difficult. Instructors were not provided with sufficient training or support in the use and maintenance of the simulators, nor were necessary replacement parts readily available. The reinforcing and problem-solving features of the simulators were seldom used, nor were students allowed to operate the simulators alone or in small groups. Recommendations are made that (a) the basic cockpit procedures training objectives of the FAM courses be recognized

officially, (b) completely documented training scenarios which relate simulator use to specific behavioral objectives be developed, (c) better maintenance support--0-level training and parts--be provided, (d) improvements be made in the rear projection visual system and panel replacement, and (e) IMI (Instructor Managed Instruction) procedures be adopted in order to avoid problems associated with differences in student aptitudes, skills, and experience, as well as variations in instructor delivery and organization. Implementation of these recommendations should result in better use of CPTs (Cockpit Procedures Trainers) and improved aircraft performance. A summative evaluation of the ECII-LPs should be delayed until major course modifications have been made and objective performance measures of training effectiveness have been developed.

2.0 ACKNOWLEDGEMENTS. This report was most highly dependent on the cooperation of ADCS K. I. Brant (Chief Petty Officer-In-Charge) and the instructor staff of NAMTRADET 1048, Sherman Field, Naval Air Station, Pensacola, Florida. The interest and help provided by Mr. Bob Carter, Education Specialist assigned to NAMTRAGRU, Millington, Tennessee is also appreciated. The assistance of Mr. Pete Harris in reviewing the report, and of Miss Teresa Hindman in typing the report, are gratefully acknowledged.

3.0 PURPOSE. The information and recommendations presented in this report are essentially formative in that the purpose of this report is (a) to recommend techniques and procedures for more effective use of ECII-LP simulators in aviation familiarization (FAM) training prior to a formal summative evaluation of the training effectiveness of ECII-LP simulators, and (b) to develop and recommend a design or plan for a summative evaluation of the training and performance effectiveness of the ECII-LP simulators. This report was written in partial fulfillment of a joint CNATRA/CNET SUPPORT plan to evaluate the training effectiveness of simulators which are used in several Navy undergraduate aviation training programs, including those aviation programs which use ECII-LP simulators in familiarization training. This joint CNATRA/CNET SUPPORT plan was approved in CNET Second Endorsement Code N-421 of 12 August 1975 on CNET SUPPORT letter Code N-2131 1500 of 26 June 1975. This report was written in fulfillment of CNETS Field Task Assignment No. 60082 which was assigned to manage this phase of the evaluation. The recommendations made in this report should assist instructors and program managers within and outside the Navy Education and Training Command in using and procuring this and similar training equipment in the most cost- and training-effective manner possible.

4.0 BACKGROUND. Previous research in a wide variety of maintenance training situations has demonstrated that the training effectiveness of ECII simulators is equal to, or better than, other training equipment. Other training equipment usually consists of Maintenance Training Units (MTUs) which are subsystems or components of standard, operational equipment (references 1, 2, 3, and 4). The training criteria used in this previous research include (a) the speed and accuracy of normal checklist procedures and troubleshooting performance (references 1 and 2), (b) the speed and accuracy with which maintenance manuals are used and normal equipment parts are identified and located (reference 3), (c) written post-test scores (reference 3), and (d) attitudes toward instruction and training equipment (references 1, 2, and 4). These findings have also demonstrated that the ECII simulators are more cost-effective than other training equipment (references 2 and 3).

The ECII simulator is manufactured in the following two models: the ECII which is contained in a compact, desk console for individualized training, and the ECII-LP which consists of a large, mobile, mainframe for group demonstrations and lectures. (Most of the research cited above has analyzed the training effectiveness of the ECII-LP models.) As shown in Appendix A, both models have removable display (student) panels, and a visual system consisting of a random access projector and a rear projection screen. The rear projection visual system can present 100 slides for each training scenario. Both models operate from similar minicomputer and software logic systems. Although the two dimensional configuration of the display panels limits structural fidelity for the Navy aircraft systems which are simulated, the functional fidelity of the models is extremely high (reference 4). This high level of functional fidelity appears to be accounting for the training effectiveness of these simulators in the research previously cited. This research has centered around O-level maintenance training, which consists largely of knowledge of cognitive factors--parts identification and comprehension of the functional relationships which exist among the components of an equipment system. The current ECIIs appear to be especially suitable for this type of training. Although the low level of structural fidelity probably makes the ECIIs unsuitable for advanced training of complex psychomotor procedures, this deficiency may be overcome in the next generation of EC simulators--the ECIIIs--which will have full scale, three dimensional ("wrap around") consoles and mainframes.

Underlying the functional fidelity and training effectiveness of the ECII-LPs is the minicomputer and associated software. These characteristics provide the ECII-LPs with programming and reliability advantages which are not found in MTUs. Programming permits the simulator to be interactive, as well as easily updated as functional modifications occur in associated operational equipment. The electronics contained in the minicomputer make the simulator highly reliable and maintainable.

The high functional fidelity and interactive characteristics of the simulators may not, however, be used extensively in most of the Navy aviation maintenance programs for which the simulators have been procured. This conclusion was made from the training situations analyzed in references 3 and 4. As mentioned above, the performance criteria used in these evaluations was limited largely to parts location on operational equipment. This limitation was necessary not only because dedicated aircraft could not be spared, but also because the students were not prepared to troubleshoot test problems, or even describe the procedures involved in troubleshooting the test problems. This performance effect indicates that much of the maintenance training program had involved rote learning and memorization, and that functional relationships among systems and system components were not well understood by the students. The functional fidelity and interactive characteristics of the ECII-LP apparently were not being used as an integral part of the training program. Inasmuch as these characteristics account for much of the costs associated with ECII-LP simulators, the failure to make appropriate use of these characteristics reduces significantly the cost-effectiveness of the simulators. In fairness to the course instructors, however, they were not provided with adequate instructional support, either in the form of training scenarios or simulator training methodology. They appeared therefore to use the ECII-LPs in much the same way as they had used the MTUs previously--as training aids for demonstrating parts location and overall (normal) systems operation.

In recognition of the above limitations and advantages of ECII-LPs in maintenance training, the following observations were made of aviation familiarization courses--one which used ECII-LPs and the other which used more conventional training aids (MTUs, study guides, and transparencies). The participant-observer method was used in making these observations--i.e., the author participated as a student in the two courses, being exposed to the same training situations as any other student and taking the required tests. The observations emphasize the functional descriptions of aircraft systems which were made in these courses, and the techniques used to present these descriptions. Recommendations for evaluating the training effectiveness of these techniques will also be made.

5.0 METHODS. The following section contains a description of the courses which were observed, and the interviews made, in conjunction with this analysis.

5.1 Course Descriptions. Two courses were observed--the pilot familiarization course for the T-2C aircraft (referred to below as the Pilot FAM course), and the NFO (Naval Flight Officer) familiarization course for the TA-4 aircraft (referred to below as the NFO FAM course). Pilot FAM used ECII-LP simulators, while NFO FAM did not. Both courses have been offered for a number of years, and the ECII-LPs had been used in the pilot FAM course for over a year prior to the present evaluation. In addition, both courses were taught by the same three instructors.

The pilot FAM course lasted about 18 hours (from 0800 Wednesday to 1100 Friday), including several hours for review and an hour for testing. The total enrollment was six (including this author), and the aviation background of the student group was varied (consisting of Navy and Marine undergraduate student pilots, and prospective T-2C instructor pilots). (This class size and composition apparently is typical of this pilot FAM course.) Although the purpose or specific behavioral objectives of the course were never presented (similarly with the NFO FAM course), the assumption is made that the course emphasized knowledge factors, especially the location of indicators and control knobs, handles, and switches (referred to below as displays and controls), and the conditions (normal and emergency) under which these displays and controls would become operative or should be operated by the pilot. Display and control information was divided according to the eight major aircraft systems--electrical (E), instruments (I), canopy/ejection (CE), oxygen/life support (OLS), air conditioning/pressurization (ACP), power plant/fuel (PPF), hydraulics/flight control (HFC), and communications, navigation, and identification (CNI). For each system this information was further subdivided into forward cockpit (instructor pilot) and aft cockpit (student pilot). (In NFO courses, the NFO student would be located in the aft cockpit.) This subdivision was made in order to inform the student about transfer of system control between cockpits, especially the conditions under which transfer could occur and the conditions (emergency and training) under which one cockpit (usually the forward cockpit) would retain or override control from the other cockpit.

For the pilot FAM course, the ECII-LPs were used as the primary instructional device for every system except CE and OLS. Although an ECII-LP was available and used for OLS, much of the information for this system was presented by film and transparencies. An ejection seat had been removed from a T-2C aircraft for use as an MTU in CE instruction. A study guide and transparencies also supplemented instruction for the eight aircraft systems. The study guide and lectures provided most of the information about critical (normal and emergency) conditions and parameters under which the various systems would operate or should be operated (altitudes, speeds, pressures, weights, temperatures, and so forth). A workbook which consisted of completion and matching questions was also provided to each student. These questions emphasized the most important information in the course, and also contained most of the 40 test items on the final test (as stated by the instructors at the start of each instructional unit).

The NFO FAM course was similar to the pilot FAM course, except that (a) the subject aircraft was the TA-4 (a more advanced, complex jet aircraft than the T-2C), (b) the students were NFOs and not pilots, and (c) ECII-LPs were not available. The student group was larger (about 30) and less varied (only Navy and Marine undergraduate NFOs) than was the T-2C student group. NFO FAM lasted about 11 hours (from 0800 Thursday until 1100 Friday), and included information about the same eight aircraft systems which were covered in the T-2C course. Less information was provided about the forward cockpit and about direct aircraft control in the NFO FAM course than in the pilot

FAM course because the NFO students are only transitioning through the TA-4 aircraft prior to more intensive flight instruction in more advanced aircraft. Inasmuch as the NFO student is not required to operate this aircraft in flight, the major purpose of the TA-4 NFO student instruction is to introduce or familiarize the student with more advanced, high performance, jet aircraft and the normal and emergency conditions (and associated display and control information) under which these aircraft operate. This information will permit the NFO student to assist the pilot in monitoring critical display information during flight, warn the pilot if emergency parameters and conditions are indicated, and take appropriate corrective action if the situation warrants. Inasmuch as transfer of TA-4 aircraft control to an NFO student would usually be limited to emergency conditions, emphasis in the NFO FAM course was placed on those systems most likely to be monitored and operated under such conditions--I, CE, OLS, and CNI. (CNI is also important to the normal aviation tasks performed by NFOs.) Transparencies and student guides were the primary training aids used in the NFO course. These training aids supplemented the critical conditions and parameter information which was provided by lectures in much the same fashion as the ECII-LP did in the pilot FAM course. The NFO FAM course also contained a workbook of completion and matching questions which was used by the students to prepare for the 50-item final test.

The typical instructional unit in both FAM courses was centered around one of the eight aircraft systems, was delivered by a single instructor, and lasted from one to three hours (with a 10-minute break every 50 minutes). The unit began by having the instructor explain the purpose of the system and the location and operation of important system components (which was demonstrated on the available training aids). During these demonstrations, the instructor would either write critical operating conditions and parameters on a chalk board or refer to the study guides for this information. Normal system operation was usually explained first, followed by operation under emergency conditions. (Emergency conditions which resulted from the failure of components within the subject system or failures within a support system.) Occasionally, after covering this information, an instructor would progress through a scenario involving several of the emergency conditions previously presented. The instructional unit ended by having the instructor review questions from the workbook (the answers to about half of these workbook questions were solicited from the class as a whole). Both FAM courses could be briefly described as rapidly paced, competitive, and highly demanding (the student would probably have to spend at least two or three hours a night after class memorizing and organizing the information sufficiently well to earn over 90% on the final test--even with the information provided in the workbooks).

5.2 Observation Procedures. As mentioned earlier, this report is essentially a formative review of the FAM courses, and is based largely on observation of training (instructor) technique-, classroom (student) responses to these training techniques, as well as interviews with instructors and students. Quantitative or statistical data were not collected or used. Recommendations will be made, however, about the quantitative data which may be most reliable and valid if future summative evaluations are undertaken. A summative evaluation would be in keeping with the purpose of these observations and recommendations, which are presented not only to modify the training programs, but to recommend modifications which can be tested for validity using more appropriate analytical and statistical procedures.

6.0 RESULTS AND DISCUSSION. The following sections describe the observational and interview findings, and the interpretations of these findings.

6.1 Instructor Findings. Observation of instructor techniques in both FAM courses indicated that the ECII-LP made the presentation of training information better organized and more convenient than MTUs, transparencies, or the chalk board. These advantages could be most readily demonstrated by observing the use of the ejection seat MTU in the CE unit of both courses. This device was heavy and awkward to move, difficult for students to observe (observation was limited to about half a dozen students), and poorly configured for instruction (critical components were not labelled or well marked and could not be activated). (An ECII-LP or some other training aid should be made available for the CE instructional unit.) The instructors could make easy and direct reference to system components on the ECII-LPs, and ECII-LP panel graphics had excellent two dimensional fidelity and were highly visible. The transparencies which were used, although accurate in outline form, had low structural fidelity and could not be seen as well as the ECII-LP panels because of poor use of color and because projection lighting was too intense. The transparencies were also more difficult for the instructors to handle--they often searched through several transparencies before finding the correct one, and then occasionally reversed the projection. As mentioned previously, the ECII-LPs had the added advantage of showing the functional flow or relationships between systems and system components. This feature permitted the instructor to deactivate a system component (or support system) and readily demonstrate the operational effects, and then demonstrate which auxillary systems or components would correct the faulty condition. At least two shortcomings were noted in this feature, however. First, the direction of the functional flow or relationship was not evident (this information had to be provided by the instructor). Secondly, the same color of lights was often used to designate functional relationships between primary and auxillary components and systems, making differentiation between these components and systems difficult. The usefulness and necessity of this feature in the present training context may be questionnable as well. Much of this functional information could be presented on a set of carefully prepared slides which show the sequential deactivation and activation of primary and auxillary systems and components. In addition, the FAM instructors, similar to the aviation maintenance instructors who were referred to previously, seldom used the ECII-LPs for the purpose of demonstrating functional relationships between primary and auxillary systems. Although they (the FAM instructors) spent a significant portion of each unit describing emergency conditions and procedures, little was done to demonstrate this information on the ECII-LPs. (They used the chalk board more often for these demonstrations.) Those ECII-LP demonstrations which were performed were occasionally ineffective, usually because incorrect program inputs (scenario conditions) were entered into the ECII-LP minicomputer or (more rarely) because of some unreliability in the computer electronics.

Several other characteristics were noted in the ECII-LP which may distract from the use or training effectiveness of the device. Despite the mobility of the device, the panels required at least two instructors for replacement. This procedure occasionally took 10 to 15 minutes while another instructor was being located, and replacement did not always coincide with a regularly scheduled 10-minute break. Another shortcoming was found with the random access rear projection visual system. Many of the programming difficulties mentioned above appeared to be related to this system, which was used to display (a) critical parameter information associated with the training scenario being programmed on the panel, or (b) interactive information such as whether or not the faulty condition had been corrected. The difficulties involved miscuing between the rear projection visual system and the scenarios which had been programmed on the ECII-LP panels. (For example, while demonstrating ignition of the second engine on the T-2C aircraft during a deck battery start, the ECII-LP panel would show the first engine at 65 percent D.C. power followed by ignition of the second engine, while the information on the rear projection visual system read "bring first engine to 65 percent D.C. power.") Miscuing appeared to be especially disturbing to the instructors, perhaps because they were afraid that they were perceived by the students as incompetent to operate the device, or unknowledgeable about the material.

These miscuing effects probably were involved in the instructors not using the device more to demonstrate functional flow and emergency procedures. Most of the training scenarios could be presented on the device without this visual support and still be of some training benefit. Worthwhile interactive features (if operational) would be lost, however. In addition to these programming or miscuing difficulties, many of the rear projection visuals could not be seen adequately (even by students sitting in the second row within 12 to 15 feet of the device). Most of the poor visuals included photographs of the aircraft (such as doors, bays, receptacles, guages, and so forth). These visual problems were most likely related to (a) poor photography and photographic development (especially inadequate contrast and perspective between subject and field), (b) poor resolution of the visuals through the projection system and on the screen, (c) the small size (12 x 12 inches) of the rear projection screen (which should be at least double this size), and (d) poor lighting in the classroom. Much of the information provided by the visuals was also duplicated on the panels, in the study guides, or by the instructor. Except for those visuals which presented interactive information (which, as mentioned above, was used only rarely in the present course), the visual system could best be described as a redundant and unnecessary appendage to the ECII-LPs.

Interviews with the instructors indicated that they generally were pleased with the ECII-LPs, largely because the device (and instructional delivery) were more compact, organized, and convenient than other training aids. They acknowledged that they device was extremely useful in demonstrating functional relationships among systems and in training emergency procedures. Several instructors stated that the device appeared to improve final test performance by an average of five to ten percentage points. Although accurate comparison data were not available to substantiate these opinions, a review of the final grades for both FAM courses showed performance to be uniformly high, with few failures. The student pilots did better on the average than the student NFOs, but this difference may have been related to variations in length of training, aptitudes, and testing procedures. The instructors did not complain about the programming problems previously mentioned, but several of the instructors stated that the rear projection visuals were inadequate. Although they were satisfied with the overall reliability of the ECII-LPs, they did complain that maintenance support was a major problem. Troubleshooting schematics were not available for the minicomputer, visual system, or panels, nor could spare parts be obtained locally. Troubleshooting and minor repairs were therefore dependent on a few experienced instructors, a procedure which is inefficient because of the lengthy and spurious OJT involved, as well as interference with regular instructor duties. Such a maintenance procedure can be easily jeopardized if these experienced instructors are unavailable. Procurement of major parts and servicing involved the usual requisitioning procedures, with consequent delays ranging from several weeks to months. These shortcomings seriously degrade the maintenance advantages of the device.

Although not mentioned by the instructors, the above observations on use of the ECII-LPs indicate that the absence of support extended as well to instructional delivery. The ECII-LPs apparently were sent to the NAMTRADETs with minimal instructions or directions for using the panels effectively for training. Instructions and directions appeared to be limited to operation of the programming features. Little was done to provide the instructors with complete training scenarios or directions for the use of the functional flow, emergency procedures, or interactive features of the device, or ways in which the device could be used for individualized instruction or in peer group training situations. Again, this absence of instructional delivery support may account at least partially for the minimal use of the ECII-LPs in demonstrating functional flow characteristics and emergency procedures and conditions.

In order to improve the maintenance and training effectiveness of the ECII-LPs, the Navy should procure the schematics and parts necessary for local O-level maintenance, as well as a set of detailed and organized scenarios for use by instructors in demonstrating normal and emergency aircraft system operation. In the current training situation, these scenarios should cover complete instructional units, and should integrate the ECII-LPs with other existing training aids (especially transparencies, films, and study guides). If the current training situation is modified as recommended below (see section 6.3), these scenarios should prescribe methods of using the device for individualized or peer group training.

Although the instructors were highly knowledgeable about most of the aircraft systems which they taught, and were competent in the operation and maintenance of these systems, the present observations provide evidence that the style in which they delivered the instruction may have lessened overall training effectiveness. The instructors often presented the material in a stereotypic and rushed fashion, and they appeared to be uneasy in presenting a few of the instructional unit. These effects may be explained partly by the immense volume of information which had to be presented, but this explanation still begs the question of poor organization, as well as the general perception by this author that the instructors probably did not like being the focus of, or having responsibility for, much of the instructional delivery (at least under the present conditions). Organization could be improved by removing some of the information (especially that information about the operation and maintenance of system components), and emphasizing instead (a) the normal and emergency display data which pilots or NFOs should monitor routinely during ground inspections, pre-flight checks, and in-flight operations, and (b) the prescribed (NATOPS) control operations associated with these displays. (For example, the operation of inverters, including input and output voltages and currents, or a detailed description of power plant structure and operations, such as the number, purpose and operation of inner guide vanes and fuel nozzles, should be eliminated or subsumed under more advanced training.) Training delivery support, in the form of complete training scenarios which integrate the ECII-LPs with other training aids to meet specific behavioral objectives, should also improve instructional organization and effectiveness. Many of these modifications (scenario planning, reduction of inappropriate training content, development of better training aids) could be accomplished by the instructors if they could be relieved of routine and repetitive lecture duties.

The above observations and findings indicate that both FAM courses would probably be more effective if the courses were managed under IMI (Instructor Managed Instruction) procedures than if limited instructor resources continue to be used primarily for lectures. (The small student load and the small number of instructional units probably does not warrant implementation of CMI--Computer Managed Instruction--procedures unless some cost-effective interface could be made with a large CMI system such as that operated by the CNTECHTRA.) IMI would not only provide for better use of training aids and instructor resources, and improve motivation among the instructors, but the resulting standardization would reduce differences in student performance that result from the highly variable lecture and delivery styles of the instructors (including instructional organization, the use of extraneous material--i.e., "sea stories" and jokes--and the performance differences which are related to factors such as instructor attitudes and voice communication--especially voice projection and dialect).

6.2 Student Findings. As mentioned previously, the aptitudes and aviation experience of the students, especially those students enrolled in the pilot FAM course, was highly mixed and diverse. Even among the more homogenous NFO students, observations indicated that the aptitudes required to learn or memorize the volume of information which was presented varied substantially. This author noted that perhaps as many as one-fourth of the students in the NFO FAM course were being assisted ("carried") by other students to some extent, either because those being assisted did not understand the information being presented or because they had poor study skills (or some combination of these two factors). The observation was also made that specific students in the NFO course were primarily responsible for taking notes and organizing the material on discrete instructional units (probably as a result of the proficiency which they demonstrated in these subject matter areas in previous courses). During the hourly breaks and after class, the students would form into small groups of three to six students, and one or two members of these small groups would debrief the other students on the material just covered. Apparently, the students conducting the debriefing were recognized by the other members of the group as outstanding in these subject matter areas, and the notes which they took and the subsequent debriefings were used to supplement (not substitute for) the information gathered by the other students. Inasmuch as most aviation students are college graduates, this procedure may have originated from the practice of some college living groups to retain the notes of outstanding students in specific college courses for reference and study purposes. This procedure was much better organized in the NFO FAM course than in the pilot FAM course, probably because the NFO class was larger (so subject matter excellence was more evenly distributed), and because most of the students in the NFO FAM course (unlike those in the pilot FAM course) were members of a single training group or class which has been together during most of the undergraduate training period (so subject matter excellence could be more reliably identified). These observations appear to provide evidence for the following two interrelated effects: (a) the formal course material or structure, at least in the NFO FAM course, was not matched to the aptitudes and skills of individual students (either because of inadequate training support and organization, or because of the rapid pacing), and that (b) these training deficiencies may be effectively compensated for by peer groups which were organized much earlier in the undergraduate training period. Had the content of the study guides, workbooks, and final test required less rote memorization of locations and functions and more understanding of procedures and the relationship among systems and subsystems, this peer group process would probably have been less effective because the material would have been more difficult to organize and integrate.

The training effectiveness of the ECII-LPs is difficult to determine under these comparison conditions. In the pilot FAM course, in which the ECII-LPs were used, the students seemed less confused. The student pilots asked fewer questions than the student NFOs, especially questions which duplicated material which had already been presented by the instructor such as the location of displays and controls or review of basic procedures. The questions which the student pilots asked emphasized variations or extensions of procedures which had been described previously by the instructor. In addition, much whispered discussion occurred between student NFOs while the instructors were lecturing, indicating that information was being missed or was not being presented in a comprehensible fashion. The student NFOs did not appear to comprehend the functional relationships among system components which were presented on transparencies or other training aids as well as the student pilots understood similar information presented on the ECII-LPs. Although student use of the ECII-LPs occurred only rarely, the occasions on which the student pilots were provided with an opportunity to practice procedures (such as hot starts, false starts, and air starts) appeared to be highly reinforcing to the students and to the learning process. Both the students who were practicing on the ECII-LPs and the remaining students in the classroom participated in the scenario, and they responded favorably to this opportunity to apply and integrate the information which had just been presented by the instructor (although the scenario, as previously noted, may not have been well planned).

The differences observed above between student pilots and NFOs (confusion and incomprehension demonstrated by student NFOs through frequent and redundant questions, whispered discussions during lectures, and peer group debriefings) could be attributed to several factors, including use of ECII-LPs, the larger NFO class size, the shorter NFO course, and the lesser operational flight experience of the student NFOs. Questions about the location and operation of displays and controls by student NFOs could be related to (a) inferior presentation of this information by the available transparencies and study guides compared to the ECII-LPs (which seemed to be the case to this author), or (b) to the lesser emphasis placed on this information by the instructors in NFO classes. As mentioned previously, the present observations did not permit a determination of the extent to which each of these factors may account for measures of training effectiveness. Such a determination will be possible only through a formal, summative evaluation such as that proposed in the last section of this report.

6.3 Discussion of Instructor and Student Findings. The above observations indicate, and this author strongly recommends, that a formal, summative evaluation of the training effectiveness of the ECII-LP simulators should probably not be undertaken until minor modifications have been made in the design and support of the ECII-LPs, and some major modifications have been instituted in the management and delivery of the existing pilot and NFO FAM courses. Summative evaluations will most likely always be difficult to initiate because of continual, minor modifications in training programs and delivery systems, but in the present case, in which both major and minor modifications are indicated, conducting such an evaluation would be wasteful of personnel and funding resources. In addition, a summative evaluation would be difficult to implement in the near future because two training situations do not currently exist which have the same (or similar) students, subject aircraft, and training objectives, and which differ only in the availability of ECII-LPs. (The present pilot and NFO FAM courses cannot be compared validly and objectively for ECII-LP effectiveness because of dissimilarities in students, subject aircraft, and training objectives.)

The major problem found with both FAM courses is that the training objectives include not only familiarization training, but have apparently been expanded to include basic cockpit procedures training as well. Such an expansion is probably a normal (although unofficial process in these training situations. Strict familiarization training should encompass the simplest learning levels within the cognitive domain of training developed by Bloom (reference 5). These levels would include rote memorization of the identity and location of displays and controls, and recognition or recall of the basic information which is conveyed in the displays or the primary operation which is performed by activating each control. Training problems begin to arise, however, if the objectives also include an understanding of the systems which underlie displays and controls, primarily because displays and controls are usually associated with several systems which interact in complex ways. By knowing these interactions, the pilot (or NFO who may be assisting the pilot in monitoring the displays) can determine which systems to activate or deactivate should emergency conditions be displayed. In order to understand systems interaction, the training objectives may include knowledge of the critical points (at the component level) at which various systems interface (the points at which functional relationships between systems or subsystems are established). This understanding may be necessary because guages or sensors are often located at these points and these guages and sensors are usually checked for normal operation during the ground or pre-flight inspections. Also, by knowing whether the interface between systems is electrical, mechanical, or hydraulic, the pilot or NFO can determine whether or not auxiliary systems will be operative under specific emergency conditions involving electrical, mechanical, or hydraulic failures. This information will enable the pilot or NFO to perform the most appropriate emergency procedures. Often, several interfaces may exist within a single system (especially the electrical system) in which several parallel or auxiliary subsystems can be activated or deactivated in order to maintain power to specific equipment under emergency conditions. An understanding of these subsystem interfaces requires learning and memorizing of the function of many components. Unfortunately, this understanding often involves the presentation of complete systems and subsystems, and the subsequent learning and memorization of unnecessary components that are intermediary between interface points and that are not critical in the detection of failure in a critical system or subsystem. On several occasions in the present courses (especially in the E and HFO instructional units), the instructors described many of the components which could be involved in faults, but which would result in the same display information. A noteworthy observation is that the instructors would usually have to refer to the study guides, transparencies, or chalk boards instead of the ECII-LPs to present this information. Apparently, the information presented on the ECII-LPs was more selective, and limited to that information which was necessary only to detect faults and take appropriate action.

The above discussion, as well as the observations made previously, demonstrate that the term "familiarization" for these courses may be a misnomer. Both the pilot and NFO FAM courses consisted not only of familiarization training, but basic cockpit procedures training as well. Official recognition of this basic cockpit procedures training should be made, both in the title and in the organization of the course. Inasmuch as the next course taken by these students is CPT (Cockpit Procedures Training), a TSA (Training Situation Analysis) should be made of the training objectives which are actually trained in the current FAM and CPT courses, and these objectives should be integrated in order to avoid overlap and to make the most effective use of available training aids (especially the ECII-LPs). This TSA should determine which component and subsystem information is truly enabling in the development of terminal training objectives in the CPT and aircraft.

The above observations and interviews indicate that the present FAM courses could be divided into at least three phases, with the ECII-LPs being used only in the final phase. Phase 1 would be strictly familiarization training, involving recall of the identity and location of displays and controls, as well as recall of the primary purpose and operation of these displays and controls. This phase should expand on that familiarization information which is currently offered, and present this information in a better organized fashion, free of functional system descriptions and procedures (which would be presented in the next two phases). This information could be effectively presented in well prepared study guides, transparencies, and audio-visuals (sound/slide). Phase 2 would consist of understanding critical system and subsystem interfacing, including functional relationships between systems and subsystems under normal and emergency conditions. This training could also be accomplished with the above training aids. (This phase would most represent the FAM courses which are taught presently, but would consist only of that information which is necessary to understand the functional relationships among systems and subsystems and which is associated with activation and deactivation of displays and controls.) The final phase would be a practice or applications phase in which the ECII-LPs would be used to present normal and emergency scenarios to the students. Students would practice ground inspections, pre-flight checks, and normal taxi, take-off, and in-flight procedures, as well as emergency procedures (including hot starts, air starts, and activation of OLS and CE equipment) during this phase. (CE procedures training would be contingent on procuring an ECII-LP simulator for this purpose.) These three phases, arranged in this order and emphasizing the proposed content and objectives, would offer familiarization and procedures training in a progressive, systemmatic fashion, and would therefore conform closely to the first three cognitive domain levels--knowledge, comprehension, and application--established by Bloom (reference 5).

As mentioned previously, phases I and II could most easily and effectively be managed using IMI procedures, in which instruction would be individualized and an instructor would score pre- and post-tests, determine the next unit of instruction, and discuss instructional problems with each student. The IMI procedure has been found to be cost- and training-effective for aviation maintenance students (reference 6), and, as described above, the IMI procedure appears to be suitable for the present FAM training courses as well.

Phase 3 would consist of the applications and integration training levels developed by Bloom. In this phase, information from the previous two phases would be integrated and used to practice and solve procedural problems in the ECII-LPs. Some psychomotor procedural skills would also be trained, although most of the objectives in the psychomotor domain are probably better trained in the CPT or aircraft. This author would prefer that the ECII-LPs be used in an individualized/IMI mode for phase 3. This mode would be most effective in correcting procedural problems which are unique to each student, and would also take maximum advantage of the interactive (reinforcement) features of the ECII-LPs. Such use, however, should not be formally adopted until an evaluation has demonstrated that use of the ECII-LPs in this mode reduces the number of hours required on CPT simulators or in the aircraft, or that the students entering these latter two training situations enter at a more proficient performance level than students who have used another ECII-LP training mode. The next most cost- and training-effective option probably would be to have small groups of students (not more than six) practice normal and emergency procedures on the ECII-LPs. This option would take advantage of the peer groups which appear to have already been established in some of these courses, and would permit limited reinforcement of cognitive skills learned in the previous two phases. Unfortunately, students will most likely volunteer to practice those procedures which they understand best, and may get little practice on those procedures which they know least well. (This effect may be minimized, however, by having each student outline the steps of a procedure in writing first, and then select several different outlines from among the group to demonstrate on the ECII-LP.) The least preferred option is to use the ECII-LPs in the current lecture/demonstration mode. Although this mode will probably be of some training benefit, the unique training performance deficiencies of many students will have to await identification and correction at some later stage in training (in the CPT or aircraft--which is not an effective use of the CPT or aircraft).

Whichever of the above modes is used, the requirement will still exist to provide the ECII-LP with improved maintenance and training scenario support. As mentioned previously, more should be done to supply the NAMTRADETs with ECII-LP schematics and parts, as well as complete training (procedures) scenarios and associated documentation. The development of programmed scenarios and documentation is probably beyond the resources available in the NAMTRADETs and will have to be procured from other sources with planning assistance from the NAMTRADETs. In addition, the ECII-LP visuals should be modified as mentioned previously--larger rear projection screens and use of those visuals which contain only critical procedures information or interactive information about the correctness of performance (reinforcement). The IMI procedures proposed for phases 1 and 2, however, should free the instructors to improve the organization and delivery of training materials associated with these phases. Although NAMTRADET personnel most likely could manage effectively the three training phases, the procedural context of phase 3 and the transitional relationship which this phase (and the ECII-LPs) has with the CPT and aircraft may require that this phase be managed by qualified instructor pilots/NFOs at the squadron level.

6.4. Summative Evaluation Design. The above discussion and recommendations do not advocate that the number of instructors or the number of course hours necessarily be reduced. In some instances, such as phases 1 and 2, substantial expansion of the present course can be expected, at least in the initial training evolutions. The above observations acknowledge that these courses are currently understaffed. The purpose of instituting IMI procedures, therefore, would be to make instructors available to better organize training management and delivery to meet the behavioral objectives more effectively. By reducing or eliminating lecture duties and having instructors assume responsibility for the construction of valid pre- and post-test performance measures, development of training aids, and documentation and revision of the training management process, some reduction in initial course hours may occur after several training evolutions. The validity of these recommended training modifications, however, will be whether or not the students are better trained for the CPT and aircraft, demonstrated by improved entrance level performance on the CPT and aircraft, or by a reduction in CPT and aircraft hours. (Another effectiveness measure would be the training of more procedures--especially emergency procedures--within the number of hours currently allotted to the CPT and aircraft.) A summative evaluation, therefore, should measure the effectiveness of the various ECII-LP training modes recommended in phase 3 (individualized, peer group, and lecture/demonstration) through entrance level performance measurements and instructor ratings, average total number of instructional hours (or hours/unit), and average total number of emergency procedures practiced in the CPT or aircraft. These criteria of effectiveness should be used regardless of whether or not the above training modifications are implemented. Using the current written final test would not be valid because this test does not contain a sufficient number of items to measure the procedures training which is actually being accomplished. The final test scores also do not represent a random unbiased sample of the classroom training which occurs because the instructors prompt the students about the final test items. In addition, the peer group process most likely compensates for many of the classroom training deficiencies and differences that might be demonstrated in final test scores. The initial ground inspection ("walk around") and pre-flight scores which are obtained by the student from the instructor pilot on arrival at the squadron probably are more valid effectiveness criteria than written final test scores (and would be the only valid criteria if the FAM courses involved only familiarization training). These criteria, however, would fail to measure many of the procedural behaviors that are learned in the present courses (and these procedural behaviors are emphasized even more in the proposed modifications). These criteria should be included, however, as measures of the training effectiveness of phase 1. Only by measuring the effectiveness of each of the three ECII-LP training modes on CPT and aircraft procedures training will the effectiveness of the ECII-LPs be validly tested and recognized.

If the above course modifications are implemented, and the current ECII-LPs are used in an IMI mode, then procurement of the ECII (desk console model) would be most appropriate in the future. Although the current ECII-LPs probably are as training effective as the ECIIs, the ECIIs would be more cost-effective and convenient for individualized training. In addition, the development of the EC-IIIs described in section 4.0 should be followed closely because these simulators promise to be highly effective for training many of the complex psychomotor skills currently being trained on CPTs. The EC-IIIs, in combination with the ECIIs (and using the scenario software development and programming which should be made available to the current ECIIs), has the probability of being a highly training- and cost-effective mix.

7.0 CONCLUSIONS. The conclusions listed below have been drawn from the above results:

7.1 Comparative observations between the NFO FAM course which used inexpensive training aids (transparencies, chalk boards, and study guides) and the pilot FAM course which used ECII-LP simulators indicate that the two courses did not differ substantially in training effectiveness (as inferred from student questioning, interviews, and reviews of written post-test scores). This conclusion is highly tentative, however, because of differences in aircraft, student aptitudes and skills, peer group processes, and training objectives between the two courses. The absence of objective training performance criteria for these courses also hinders any conclusion about comparative training effectiveness.

7.2 The two FAM courses (NFO and pilot) consist not only of familiarization training, but basic cockpit procedures training as well.

7.3 Although the instructors appear to be highly competent in the maintenance of special aircraft systems, they vary substantially in instructional skills, especially lecture style and management of course organization and content.

7.4 The aptitudes, skills, and aviation backgrounds of the students also varied substantially, and these factors appear to be related to the training effectiveness of the two FAM courses. In the larger of the two courses (NFO FAM), an informal peer group training process seemed to have developed in order to provide the poorer students with the additional training necessary to pass the course.

7.5 The instructors appear to favor the ECII-LPs over other training aids and devices, primarily because the ECII-LPs were easy to move, fairly compact, accessible, and organized the subject matter at a central location. The graphics, especially those on the panels, were accurate and well organized. The larger class, however, had some difficulty viewing the panel graphics from the back of the room. The basence of structural fidelity seemed to be more than compensated by the functional programming features of the simulator, as well as the overall ease of use.

7.6 Several human factors deficiencies were found in the simulators. First, the rear projection visual system was totally inadequate. The slides (except those containing only words) were difficult to see from almost any distance, and the visual system was not synchronized with the rest of the training scenario. These problems seemed to reduce instructor acceptance and use of the programmed training scenarios. The second deficiency was that the panels were too heavy and cumbersome to be replaced by a single instructor.

7.7 Instructors were not prepared to use the ECII-LPs. They had difficulty completing a programmed training scenario (even without mechanical or programming problems), and they did not integrate these training scenarios adequately with the other course materials. Most students did not have an opportunity to operate the ECII-LPs, although they seemed to favor the problem-solving and reinforcing features of the simulator.

7.8 The ECII-LPs have a high level of engineering reliability. Engineering faults, however, are difficult to correct because parts are not readily available and NAMTRADET personnel have not been trained formally to maintain the simulators.

8.0 RECOMMENDATIONS. The following recommendations are made in association with the above conclusions:

8.1 Although the ECII-LPs, as presently used, do not appear to improve training effectiveness, the simulators could be made more training effective if used properly. Effectiveness is dependent on official recognition that the FAM courses should include training objectives in basic cockpit procedures, and providing the instructors with complete training scenarios which are associated with specific behavioral objectives. The costs involved in expanding the FAM courses to provide this training should be more than compensated by better aircraft performance and more efficient use of CPTs. If the courses are not modified to provide this training, then course content should be reduced to familiarization training only. Strict FAM training should be limited to recall of the identity and location of displays and controls, as well as recall of the primary purpose and operation of these displays and controls. FAM training should not involve cognitive integration of display and control information in a problem-solving situation.

8.2 The training problems associated with variations in student aptitudes, skills, and experience, as well as differences in instructor lecture style and course management, could be corrected by implementing IMI (Instructor Managed Instruction) procedures. Under IMI (and assuming that the courses would be expanded to include basic cockpit procedures training) the students should be provided with substantially more opportunity to reinforce knowledge skills by practicing programmed training scenarios on the ECII-LPs, either alone or in small groups. Use of the ECIIs (vice ECII-LPs) may be warranted in these training situations. The prospective ECIIIs also appear to be appropriate for this type of training.

8.3 Engineering solutions should be found for the problems of panel replacement and the inadequate rear projection visual system (including improved visuals and correct synchronization with the programming system).

8.4 The instructors should be provided with completely documented training scenarios, as well as lesson plans which integrate the ECII-LPs with other training aids and devices. The instructional objectives which are to be met by the ECII-LPs should also be specified.

8.5 Instructors should be provided with O-level maintenance training for the simulators, as well as a stock of necessary parts.

8.6 Until the above modifications are made in the present courses and in the use of the ECII-LPs, a summative evaluation of the ECII-LPs objective measures of training performance (in addition to final test scores) should be developed.

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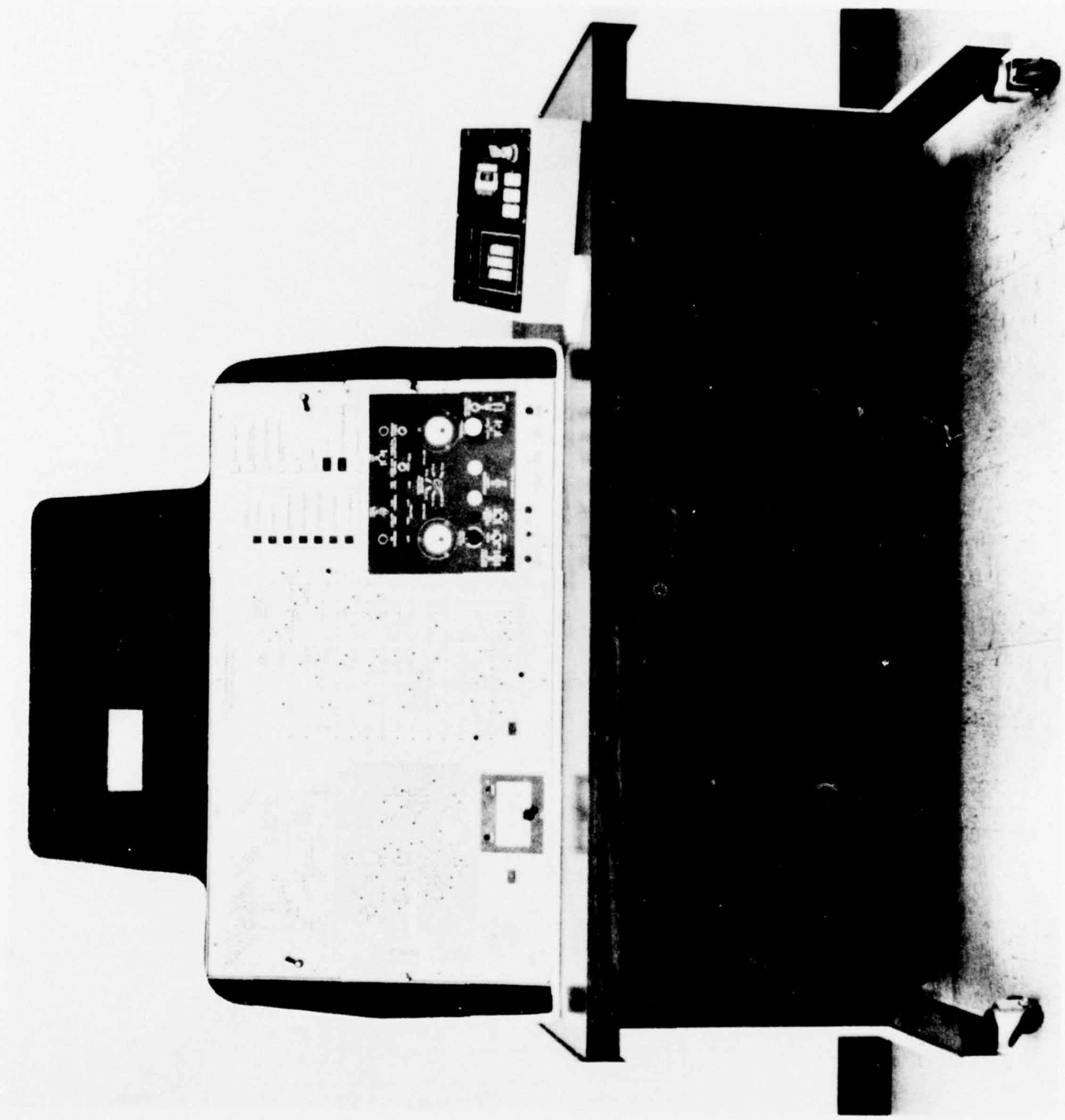
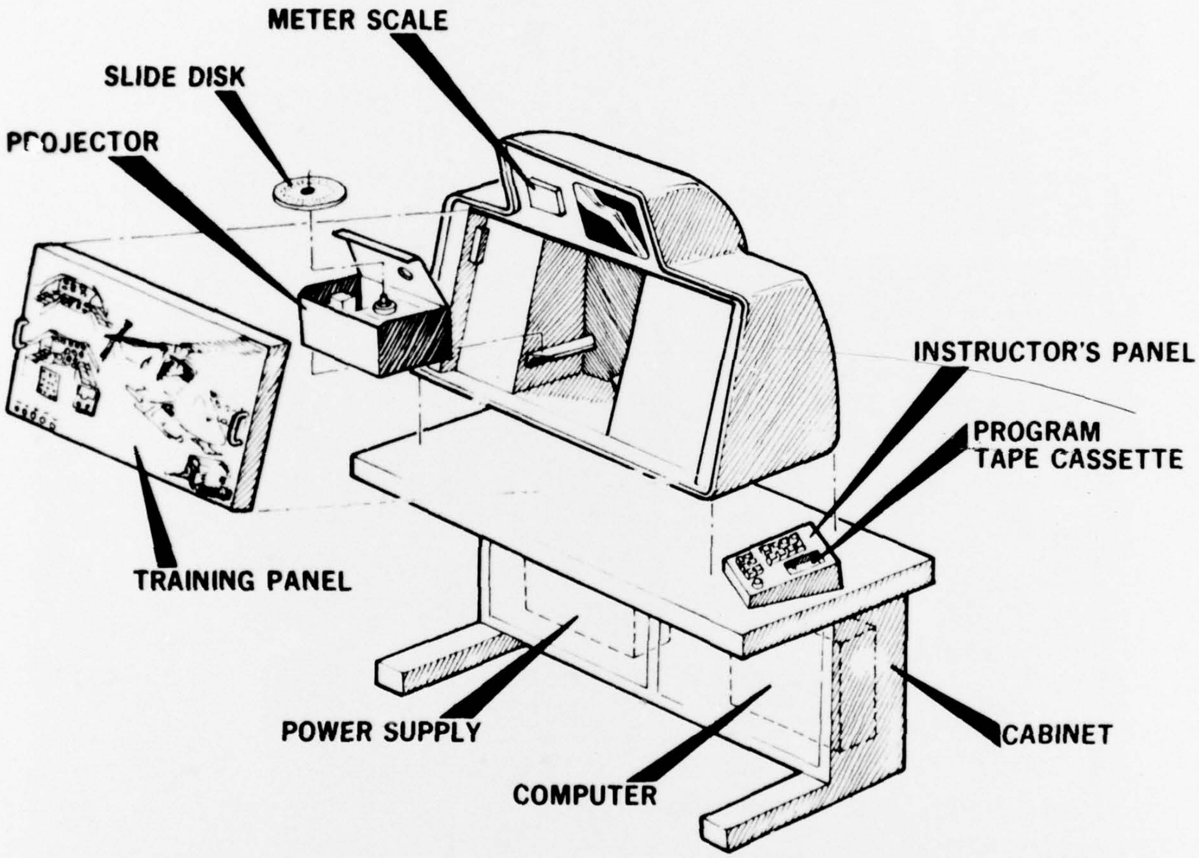
APPENDIX A

Normal and Exploded Views of the

ECII and ECII-LP Simulators



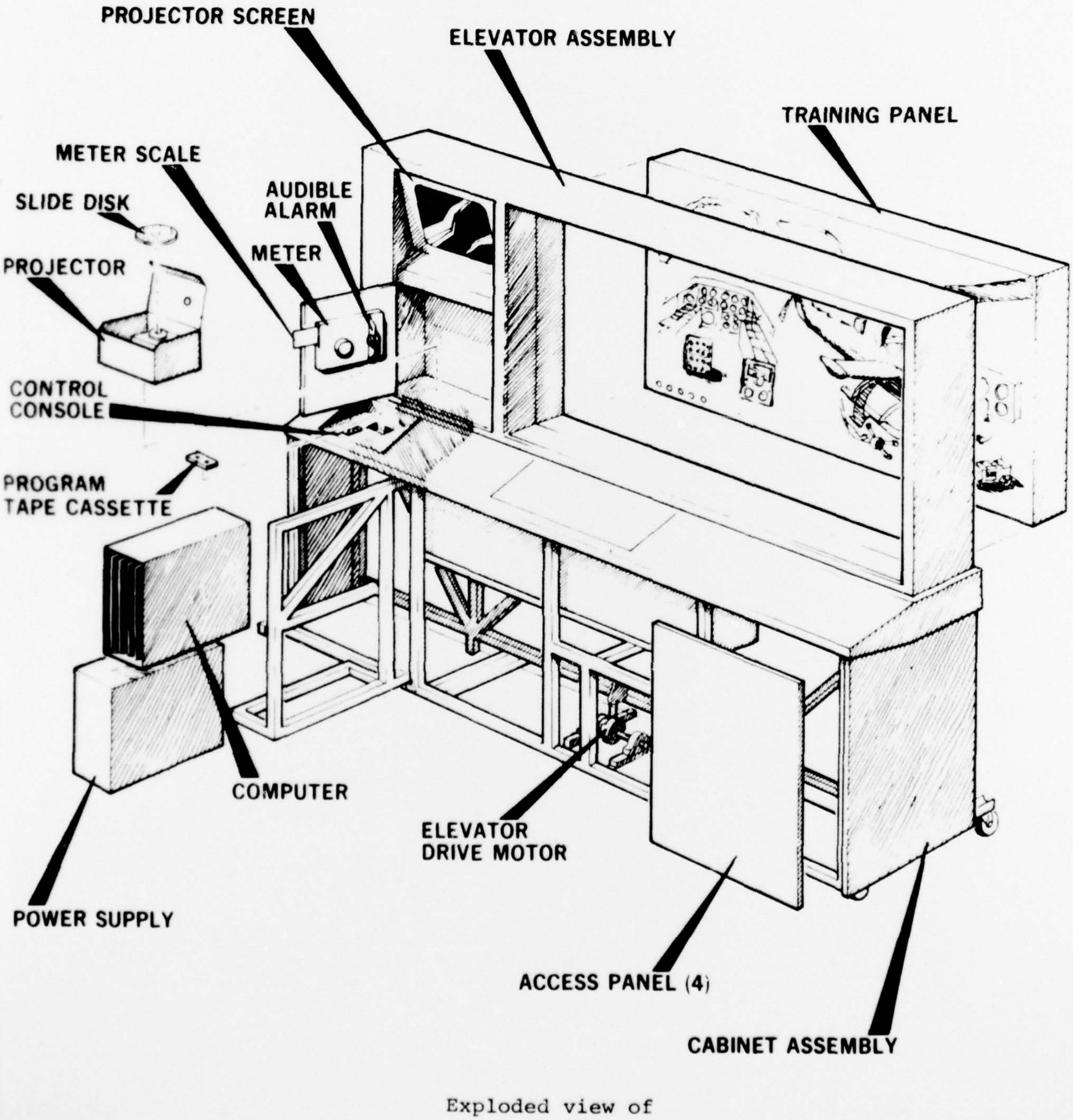
Normal View of ECII Trainer Console



Exploded view of

EC II Trainer Console

Normal View of ECII-LP Trainer Console



Exploded view of

EC II-LP Trainer Console

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Training Effectiveness	Training Objectives	ECII
Simulators	Instructor Managed Instruction	ECII-LP
Student Pilot		Fidelity
Instructor Pilot	Cockpit Procedures Trainers	Desk Console
		Mini-Computer

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

An evaluation of the training effectiveness of ECII-LP simulators was undertaken using the participant-observer method. Comparisons were made between two aviation courses--pilot FAM which used the ECII-LPs to familiarize student pilots and instructor pilots with the T-2C aircraft, and NFO FAM which used transparencies, study guides, MTUs, and chalk boards to present familiarization training, to NFO students who were transitioning

(cont on p 1473B)

to the TA-4 aircraft. Interviews, student questions, and a review of final test scores showed that the two courses were probably equally effective in meeting the training objectives if allowances are made for differences in student aptitudes and skills, previous aviation experience, and length of the training period. The observations found, however, that the courses also provided training in basic cockpit procedures although the final tests did not emphasize these objectives nor were the ECII-LPs being used effectively for this type of training. Although the ECII-LPs were highly mobile and presented training information in a well organized fashion, the rear projection visual system of the simulator was found to be inadequate, and panel replacement was difficult. Instructors were not provided with sufficient training or support in the use and maintenance of the simulators, nor were necessary replacement parts readily available. The reinforcing and problemsolving features of the simulators were seldom used, nor were students allowed to operate the simulators alone or in small groups. Recommendations are made that (a) the basic cockpit procedures training objectives of the FAM courses be recognized officially, (b) completely documented training scenarios which relate simulator use to specific behavioral objectives be developed; (c) better maintenance support--O-level training and parts--be provided, (d) improvements be made in the rear projection visual system and panel replacement, and (e) IMI (Instructor Managed Instruction) procedures be adopted in order to avoid problems associated with differences in student aptitudes, skills, and experience, as well as variations in instructor delivery and organization. Implementation of these recommendations should result in better use of CPTs (Cockpit Procedures Trainers) and improved aircraft performance. A summative evaluation of the ECII-LPs should be delayed until major course modifications have been made and objective performance measures of training effectiveness have been developed.

(cont fr p. 1473A)
As a result of this study, the following