AD/A-002 705

FIELD EVALUATION OF MODEL II OF THE COMPUTER-BASED, INDIVIDUAL TRAINER FOR THE RADAR INTERCEPT OFFICER

Joseph W. Rigney, et al

University of Southern California

Prepared for:

Naval Training Equipment Center
Advanced Research Projects Agency

July 1974

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER 73-C-0065-2	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER AD/A-002 705
4. TITLE (and Subtitle) FIELD EVALUATION OF MODEL II OF THE COMPUTER-BASED, INDIVIDUAL TRAINER FOR THE RADAR INTERCEPT OFFICER		5. TYPE OF REPORT & PERIOD COVERED Final (1 Jan. - 31 Dec. 1974) 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Joseph W. Rigney, D. Kirk Morrison, Louis A. Williams, Douglas M. Towne		8. CONTRACT OR GRANT NUMBER(s) N61339-73-C-0065
9. PERFORMING ORGANIZATION NAME AND ADDRESS Behavioral Technology Laboratories University of Southern California Los Angeles, California 90007		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 2752-02P02
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Training Equipment Center Orlando, Florida 32813		12. REPORT DATE July 1974 13. NUMBER OF PAGES 58
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution is unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

Rigney, J. W., Morrison, D. K., Williams, L. A., and Towne, D. M. Description and Initial Evaluation of a Computer-based Individual Trainer for the Radar Intercept Observer. Los Angeles: Behavioral Technology Laboratories (NAVTRAEQUIPCEN 71-C-0219-1), 1973. (cont.)

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Computer-assisted Instruction (CAI)
Radar Intercept Observer Training
Adaptive Control of Instruction
Computer Graphics

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

Model II of the basic skills intercept trainer for Radar Intercept Officers was evaluated in a school environment. Model II incorporated different instructional sequencing logic, additional weaponry capability, and additional graphic features from Model I (developed under a previous project). These added features were designed to assist the student in understanding the intercept geometry and in learning to use the B-scan display. One (N=31) of two random groups practiced on a trainer with these

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. additional graphics, the other group (N=29) used a version of the trainer without these features.

The group using the enhanced trainer took longer and required more problems to satisfy the trials-to-criterion logic used in the practice session. All students expressed predominantly favorable attitudes toward the trainer.

Two measures of transfer were used: a twenty-item post-test using different problems in a random sequence, and an inflight checklist administered during each of eleven practice flights and two training phases per student. The two groups did equally well on the post-test. The group using the enhanced trainer was rated slightly higher than the other on the inflight checklist on both of the inflight training phases.

Explanations for these results are discussed, and recommendations are offered. The principal recommendation is that the self-standing, CAI-system-in-a-terminal, having been demonstrated to be a viable and effective concept in a Naval training environment, should be developed as an attractive alternative to (1) large centralized-processor, distributed terminal CAI systems for use in remote environments, and (2) multi-million dollar simulators, for certain types of job skills training.

18. (cont)

Rigney, J. W., Morrison, D. K., Williams, L. A., and Towne, D. M. A Guide for the Application of Performance-Structure Oriented CAI in Naval Training. Los Angeles: Behavioral Technology Laboratories (NAVTRAEQUIPCEN 73-C-0065-2), 1974.

FIELD EVALUATION OF MODEL II OF THE COMPUTER-BASED, INDIVIDUAL TRAINER FOR THE RADAR INTERCEPT OFFICER

ABSTRACT

Model II of the basic skills intercept trainer for Radar Intercept Officers was evaluated in a school environment. Model II incorporated different instructional sequencing logic, additional weaponry capability, and additional graphic features from Model I (developed under a previous project). These added features were designed to assist the student in understanding intercept geometry and in learning to use the B-scan display. One (N=31) of two random groups practiced on a trainer with these additional graphics, the other group (N=29) used a version of the trainer without these features.

The group using the enhanced trainer took longer and required more problems to satisfy the trials-to-criterion logic used in the practice session. All students expressed predominantly favorable attitudes toward the trainer.

Two measures of transfer were used: a twenty-item post-test using different problems in a random sequence, and an inflight checklist administered during each of eleven practice flights and two training phases per student. The two groups did equally well on the post-test. The group using the enhanced trainer was rated slightly higher than the other on the inflight checklist on both of the inflight training phases.

Explanations for these results are discussed, and recommendations are offered. The principal recommendation is that the self-standing, CAI-system-in-a-terminal, having been demonstrated to be a viable and effective concept in a Naval training environment, should be developed as an attractive alternative to (1) large centralized-processor, distributed terminal CAI systems for use in remote environments, and (2) multimillion dollar simulators, for certain types of job skills training.

FOREWORD

The Naval Training Equipment Center is engaged in a program to advance the general state of Computer-Aided Instruction (CAI). A portion of this program, undertaken in association with the University of Southern California, is described in this and two other technical reports (Rigney, et al, 1973; Rigney, et al, 1974). The present document reports the development, field implementation and experimental evaluation of an (almost) completely automated CAI capability for teaching skills for the Radar Intercept Officer's (RIO's) job. Contributions made by this research to the state-of-the-art of CAI stem mainly from demonstrations as follows:

a. Advanced types of CAI, as employed in the present trainer, are feasible and useful in field applications.

b. These advanced CAI features are successful when one property of the training is a simulation of a job performance situation (the RIO task) which is characterized by dynamic, interactive, real-time qualities. (This type of training material is in contrast with training materials much more typically subjected to CAI applications. With these latter materials, programmed instruction, rather than job simulation, provides the model for the CAI approach; and information acquisition rather than skilled job performance, is the major outcome of instruction.)

c. Details concerning the manner in which a given feature of CAI is utilized is critical to its effectiveness in training, and these details are not always readily apparent. Results related to the latter point permit preliminary statements to be made in this report about the most appropriate ways to utilize some CAI features in training applications.

In addition, this report describes a valuable by-product of this research effort, viz., a new CAI device for RIO's which essentially is ready for use in operational training environments. This computer-based trainer has shown capabilities which suggest considerable superiority to trainers and training methods currently used for RIO instruction in terms of cost-effectiveness. Definitive evaluations of the various capabilities of the trainer, however, await its more complete development and an experimental environment more amenable to experimental manipulation and control. Under these improved conditions, the promise of superior training and transfer performance held by the computer-based aspects of the trainer would stand a greater chance to be demonstrated than under current conditions. Complete development of the trainer would permit comparisons with current training capabilities in which the present CAI program could be used as an alternative, rather than as an auxiliary, to such training. As it is, the data trend obtained, which associates a reduction in certain instructional components of the trainer with degraded transfer performance, can be considered as only minimally suggestive of the benefits that might be derived (and are expected) from such features.

At present, the utility of developing CAI materials for teaching the utilization of the AWG-9 system for maintaining the F-14 aircraft is being investigated for the continuation of research in this program.

Arthur S Blaiwes

ARTHUR S. BLAIWES
Scientific Officer

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

LIST OF TABLES (CONT)

SECTION I

INTRODUCTION

This is the second of two reports describing the results of developing and field-testing an individual trainer for the Radar Intercept Officer. The earlier field trial was a demonstration of the feasibility of using an intelligent graphics terminal as a standalone, "CAI-system-in-a-terminal" in a field-training environment remote from access to time-sharing networks.[1]

In the research to be described here, the field test was concerned with evaluating refinements in the instructional strategy, and with the instructional value of several computer graphics features. These differences between Model I and Model II of the trainer, and the experimental design, were described in detail in ARPA Quarterly Technical Report for July 1973. This description is reviewed below.

Since the performance, assisting the pilot in air-to-air intercepts, is quite complex, the trainer also is complex. Thus, this complexity is necessary even though the trainer was designed to teach only basic skills used in this performance. Therefore, the details of the instructional strategy, and of the differential treatment conditions, require rather complicated descriptions. General requirements for a CAI system of this type are discussed in a companion report.[2] The present study is one in a series of studies designed to provide an empirical basis for deriving and evaluating these general requirements. The reader is referred to that report for information about the CAI system architecture.

---

[1] Rigney, et al., 1973.

[2] Rigney, et al., 1974.

SECTION II

MODEL II OF THE RIO TRAINER AND THE EXPERIMENTAL DESIGN

ADDED TACTICAL PROCEDURES

Positioning the fighter for a Sidewinder attack requires approximately a 180 degrees turn from a heading near the Bogey Heading Reciprocal to achieve a final position astern of the bogey. The procedures for accomplishing this tactic were taught by the Model I trainer.

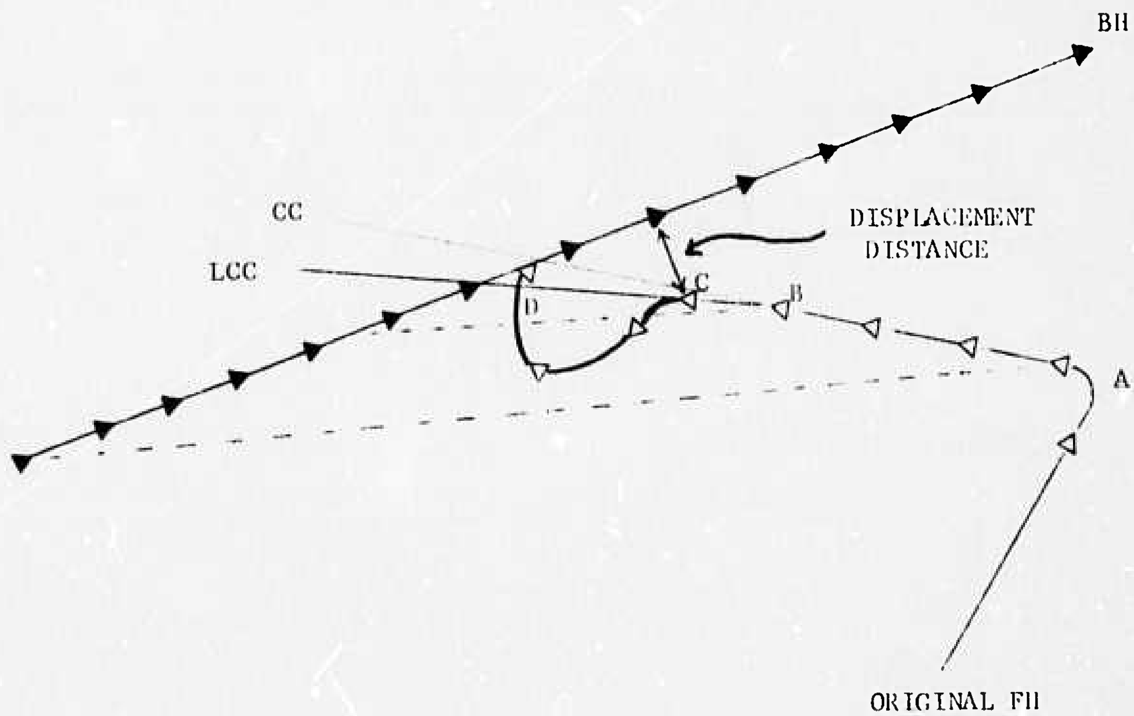
In Model II, the procedures for the Sparrow attack also are taught. The Sparrow is the first weapon fired, while the interceptor is still approaching and in front of the bogey. The fighter must be turned slightly from a collision course heading to establish a lead collision course for the missile. Then, the fighter must be leveled for firing. After firing the Sparrow, the fighter must be turned slightly again to enter the reattack turn for firing the Sidewinder. Approximate geometry is shown in figure 1.

The student RIO's task is made considerably more difficult by the requirement to make both missile attacks during a problem. He must be able to establish an approach that will allow the necessary maneuvers to be made in quick succession. To do this, he must develop a high mental information-processing rate and he must be able to shift his attention from Sparrow to Sidewinder attack requirements. This is a classic example of performance that is driven by a real-time problem. Under these conditions, the development of fluency, as indicated by short response-latencies and low error-rates, is essential.

This added tactic required several modifications to the computer program; for scoring the student's Sparrow attack, for providing a Sparrow fire display, and for recording values of student response variables pertaining to the Sparrow attack phase of the intercept. The principal new computations involved were lead collision course error for the Sparrow missile, and a score, called probability of hit (pHit).

To avoid distracting the student, graphic and numeric scores for the Sparrow attack were not displayed until he finished the reattack (Sidewinder) phase of the problem. The fire displays for the two missiles were combined in one final display. This fire display presented both graphic and numeric knowledge of results, as shown in figure 2:

a. The Sparrow Display. Bogey and fighter positions and headings at time of firing are displayed. The dotted lines in the display show the firing-range zone. The diagonal line shows the lead collision course. The hit probability X 100 must be ≥ 50 for a passing score. LCC is Lead Collision Course in degrees. Error 2L means LCC was 2 degrees too far left in this instance. TA 19 means target aspect was 19 degrees.



The bogey is on fixed course (BH) and speed. The fighter turns from original Fighter Heading (FH) at position A to a Collision Course (CC). At a short range of 8-9 nautical miles (B), the fighter turns port to establish a Lead Collision Course (LCC) for the Sparrow missile. After release of the missile and prior to 6 nautical miles short range (C) the fighter turns port to increase his displacement distance and provide turning room for the Sidewinder reattack released at point D.

Figure 1. Approximate Geometry of Sparrow Attack

b. The Sidewinder Display. The situation at the time for firing is displayed. The Sidewinder acquisition cone, the bogey heat cone, and the firing range zone are shown. For a passing score, hit probability X 100 must ≥ 80. In this problem, the student made 4 turns after turning to collision course, took 173 seconds to complete the intercept, and turned a total of 100 degrees in hard as possible turns.

c. The Simulated B-Scan with the Optimal Path (solid line) and the Track History (dotted line) superimposed. The dotted circle marks the point at which the Sparrow was fired.

ADDED INSTRUCTIONAL FEATURES

Model I instructional features were described in detail in an earlier report. They are summarized below:

Instructional Feature	When Displayed
Static, geographic plot of fighter and bogey	In Static Mode, after a computational error or, on-demand by student
Computational error knowledge of results: erroneous value disappears from toteboard, arrow does not move	In Static and Dynamic Modes, after entry of erroneous value by student
Correct answer for intercept triangle value	In Static and Dynamic Modes, on-demand by student
Sum of response latencies to complete toteboard	In Static and Dynamic Modes, after entering last value in toteboard
Free-fly Mode: Triangle values provided, dynamic triangle provided	In Dynamic Mode, if score for Sidewinder firing was < 80
Knowledge of results for Sidewinder firing	After firing Sidewinder

The above features were continued in Model II of the trainer. In addition, latencies to compute each intercept triangle value were displayed, for more detailed knowledge of results about the relative difficulties of these computations. An end-of-problem fire display for the Sparrow missile was added. The data and the diagram in (a) in figure 2, pertinent to the Sparrow, gave the student knowledge of results of his Sparrow attack.

Two new graphic features in Model II were a bogey track history and an "optimal path." Both of these were displayed on the B-scan in the free-fly mode, and in the fire displays at the end of a problem. At other times, they and the dynamic triangle were available to the student through a function key. The bogey track history and the optimal path were designed to

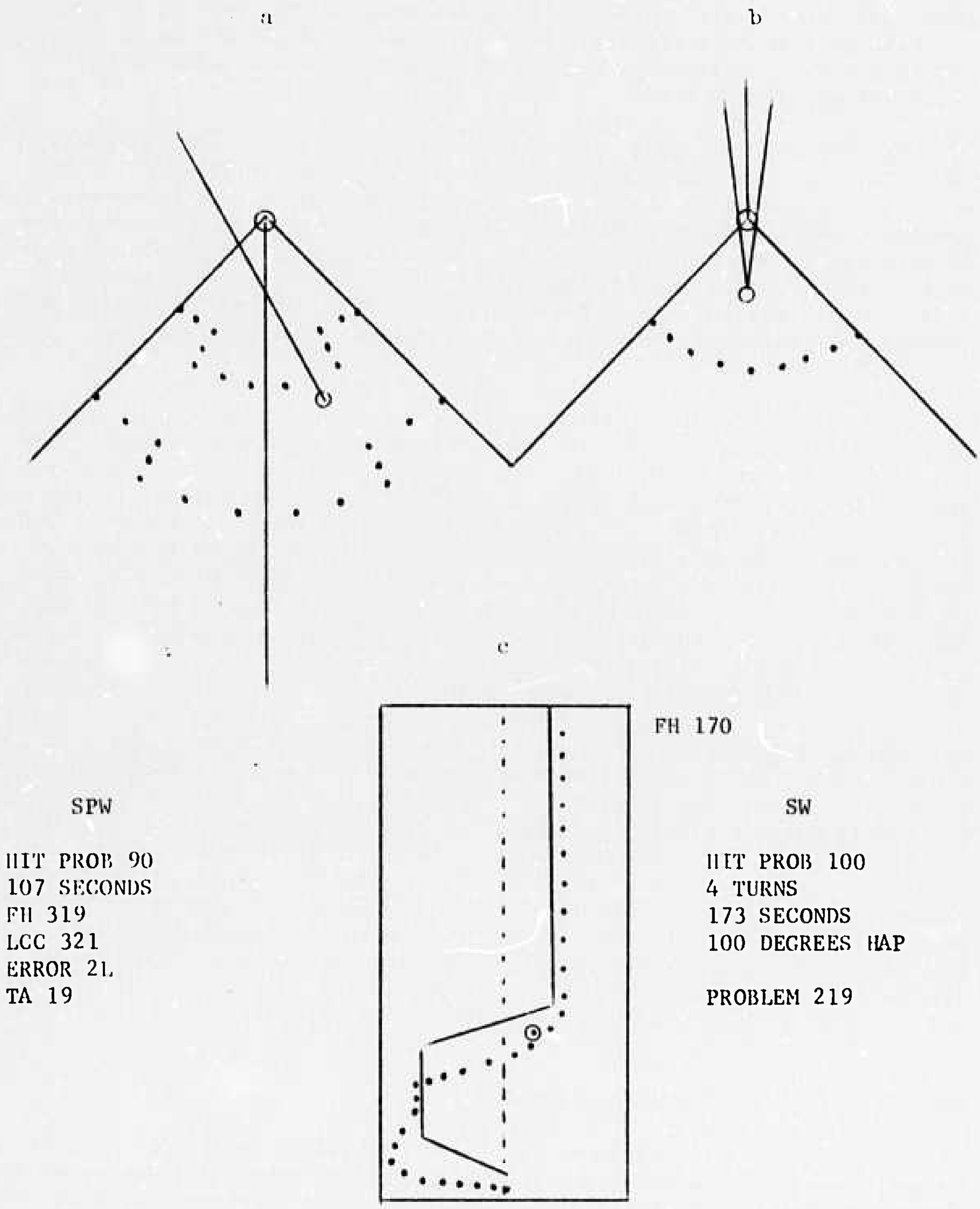


Figure 2. Graphic and Alphanumeric Knowledge of Results in the Fire Display (a) Sparrow Display, (b) Sidewinder Display, (c) B-Scan Display. See explanation in text

assist the student in learning. He could maneuver the fighter to cause the simulated radar return (the bogey) to move down the B-scan on the "optimal path" for both Sparrow and Sidewinder attacks. These displays are shown in figures 2 and 3.

The dynamic true plot, the bogey track history, the optimal path, and the fire-display geometry provided visual perceptual information to the student. By comparing the dynamic true plot of bogey and fighter positions, headings, and movements with the display on the B-scan, the student could be assisted in learning to interpret this relative motion display. He must learn a spatial frame of reference in which the B-scan becomes a window on the world fixed to the nose of the fighter, and all motion seen through this window is relative to the fighter's position, heading, attitude, and movement.

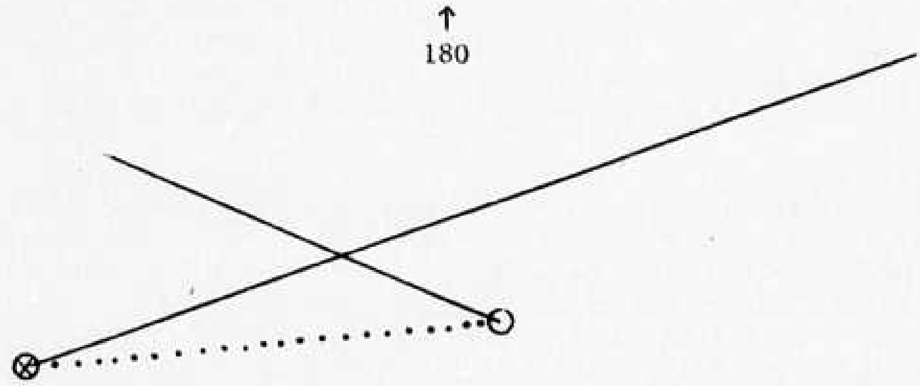
The student could superimpose the bogey track history on the optimal path display on the B-scan. As long as he kept the simulated radar blip on or very near the optimal path line, he could make a good Sidewinder intercept. A Sparrow fire marker appears on the optimal path, but the student also had to remember to turn slightly and to level out before firing. The graphic displays of situational geometry at the time of firing each missile provided quickly-grasped information that the student could use for knowledge of results. He could see immediately that he was too far away, or too far to one side, or turned too much or not enough, or had set up the wrong lead collision course, etc. He could use this information to modify his performance on the next problem.

However, in the RIO trainer, the student must be able to meet criteria of proficiency using the B-scan alone, without the presence of any of these aids, before the program will transition him to the next level of difficulty or will allow him to take the end-test. When the student is working with the trainer, most of the time he is practicing without the static or dynamic triangle, the bogey track history, or the optimal path. The presence of these particular stimulus conditions is not essential for correct responding. These features are only instructional aids which present supplementary information for the standard B-scan. Therefore, they would be expected to be most valuable in the initial stages of learning, to assist the student in understanding relative motion on the B-scan.

CHANGES IN THE INSTRUCTIONAL STRATEGY

In Model I of the trainer, intercept problems were grouped in four target aspect (TA) categories. The trials-to-criterion logic required the student to make a passing score on four successive problems, one from each of the four TA categories. Furthermore, during practice, the student cycled through the four TA categories in each successive four problems.

The instructional sequence was changed in Model II to give the students more concentrated practice in each target aspect category, and to provide an introductory problem for each TA category. Upon entering a new TA category, a student was first given a problem in the free-fly mode.



RANGE 26
SPEED 300

FH	120
BH	250
BB	85
BHR	70
TA	20R
CC	95
MUA	50L
DTG	130
AO	35L
DD	4
RG	12

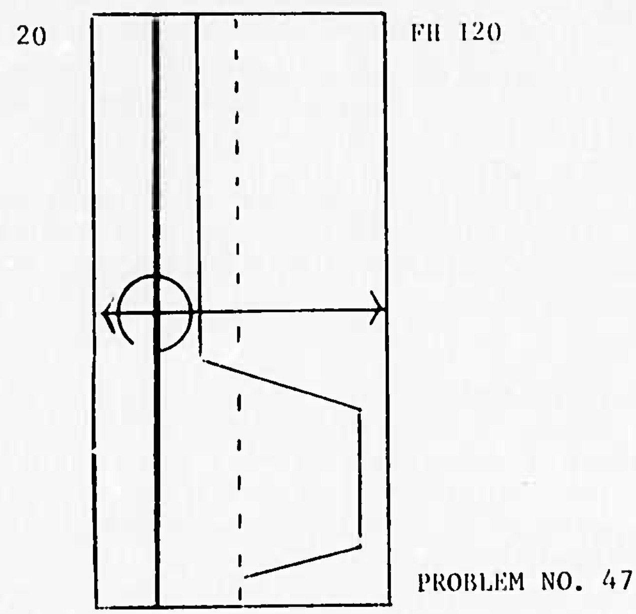


Figure 3. Free-Fly Mode with Optimal Path and Track History Added

Then he worked practice problems until he achieved passing scores on two successive problems. He then was automatically transitioned to the next TA category. There, the student repeated the same sequence.

Also, data from the first field trial indicated that the original four target aspect categories were not widely enough separated. Accordingly, only three TA categories, with greater separation, were used in Model II.

A second modification in the instructional strategy concerned the time alloted to each student. In Model I, every student was required by the school to spend ten hours on the trainer. If the trials-to-criterion logic transitioned him to the highest speed level, the student finished out his time at that level. In Model II, a student spent only as much time as was necessary to satisfy the trials-to-criterion logic and to take a special end-test of twenty problems. Thus, each student finished the course when the program logic said he was ready.

The end-test was a third modification in the instructional strategy. This was added, because we wished to test the abilities of the experimental and the control groups to cope with unexpected problems. Unlike those in the practice session, the problems in the end-test were in a random sequence with respect to target aspect. A student could not predict whether the next problem would be a low, medium, or high target aspect. Also, all test problems were run at 500 knots, 40 knots faster than the highest speed level in the practice problems. The end-test was designed to be a type of transfer test.

Other modifications related to the static triangle (a geographic plot) and the free-fly mode. When a student started on the trainer, he received three sample problems in the free-fly mode, one at each target aspect category. Then, he was sequenced to the static mode, where he practiced mental arithmetic with the static triangle visible. Upon solving two problems in succession, each with a total latency $\leq$ 60 seconds and no errors, he was transitioned to the second phase of the static mode, to practice without the triangle.

THE EXPERIMENTAL DESIGN

A number of conditions, each of which could serve as an independent variable in more rigorously controllable laboratory experimentation, were lumped together in this field trial. Under ideal conditions, a between-groups factorial design should be used, with an independent group for each combination of variables. Under field conditions, where the rate of data collection is slow, the number of subjects available over a period of three to six months is limited, and the evaluation must be conducted on a "not to interfere" basis, this is not feasible.

Students in the first field trial had expressed strong positive attitudes toward the static triangle, the dynamic true plot, the free-fly mode, and the graphic fire displays, as being helpful instructional features.

Therefore, features like this might be considered worthwhile merely to increase the attractiveness of the trainer to students. However, there would remain the question of whether these features increase proficiency, as measured by quantitative criteria. The experimental design for the field trial of Model II was planned to provide some information about this question, in terms of the possible advantages of trials with certain of these graphic features present versus "standard" practice trials in which these features were absent. The measures to be used for comparisons between groups were numbers of problems required to reach transition criteria at various stages, errors per problem, latencies per response category, values of variables measured at the time of firing each missile, scores on the end-of-course test, and ratings by instructors on an inflight checklist used in two inflight training phases.

Two versions of the trainer were developed. One was enriched by a particular pattern of graphic aids and one was not. The following summarizes differences between graphic features in the enhanced and reduced trainers:

TABLE 1. DIFFERENCES BETWEEN GRAPHIC FEATURES IN THE ENHANCED AND REDUCED TRAINERS

GRAPHICS PRESENT ONLY IN ENHANCED TRAINER	WHEN DISPLAYED
*1. Static triangle	(1) In Static Mode I until student achieved transitioning criteria (2) In Static Mode II after arithmetic error and on demand by student
*2. Dynamic triangle (Top, fig. 3)	(2,3,4) During first problem in each target aspect category (Free Fly)
*3. Optimal bogey path on B-scan (Bottom, fig.3)	(2) In Dynamic Mode, after toteboard error and on demand by student
*4. Bogey track history (Bottom, fig. 2)	(2,3,4) During repeated problem in Free Fly Mode (3,4) In Fire Display, end of problem
GRAPHICS PRESENT IN BOTH ENHANCED AND REDUCED TRAINER	**WHEN DISPLAYED**
1. Toteboard with student's entries	(1,2) In Static Mode
2. Latencies to compute each triangle value	(1,2) At start of Dynamic Mode: then all entries but FH, BH, BB cleared
3. Toteboard with automatically updated entries	(3) In Free Fly Mode: during introductory TA problem and during repetition of problem
4. Firing geometry for Sparrow and Sidewinder	(4,5) After firing Sidewinder, at end of problem: during both Practice and Test sessions
5. Alphanumeric knowledge of results for Sparrow and Sidewinder	

*These constituted the experimental treatment graphics.

Some explanation of the static mode, dynamic mode, and free-fly mode also is necessary. The static mode is "front-loading." Before a student was given a complete intercept problem, he was given a period of drill in computing the six values for the intercept triangle: bogey heading reciprocal, target aspect, collision course, makeup angle, degrees to go, and angle off. This drill was called the static mode. When he could do all six of these values with no errors, no use of the answer key, and with a total latency under 60 seconds, on two successive problems, he was automatically transitioned to the dynamic mode. In this mode, the remainder of the intercept problem was added; the student still had to compute the above six values, but the bogey and fighter were now moving at a predetermined speed. As soon as the student entered the value of collision course, the fighter started turning to that value. But, since the fighter had been moving from the start of the problem, the student's value of collision course was "late" by the amount of time it took him to do the computations to get to it.

Three introductory problems in free-fly mode started the practice session, and each time a different target aspect category was entered, the first problem was in free fly. The free-fly mode also was automatically entered if the student did not achieve the scoring criteria for the Sidewinder, pHit ≐ .80, and also, above 300 knots, for the Sparrow, pHit ≐ .50. The intent of this mode was to give the student an opportunity for "free" practice, during which he was unburdened of doing mental arithmetic. He had the above graphics, in the enhanced trainer, which he could relate to the standard B-scan. It was called "free-fly" because the student was free of the burden of computing triangle values and was free to "fly" the fighter without being scored. It was supposed to be an opportunity for the student to relax, and to take stock of what he had done wrong in the preceding problem. This mode was supposed to reduce a disadvantage of the trials-to-criterion logic for adapting to individual differences; students are practicing "taking the test" all the time with this logic, which constrains the learning process to intensive practice. No scores or other data were collected when a student was in free-fly mode.

It will be recalled that adaptive control logic is used in the trainer; that is, each student progresses at his own rate and must meet successive transitioning criteria. The more able students will work fewer problems to get through to the end than the less able students. However, all students started with the same problem sequence at the beginning of each different speed level and target aspect category.

A transfer test was given to all students from both groups when they were transitioned out of the top speed level. The hypothesis was that those students who achieved an understanding of the true and relative geometry involved in the intercept tactics, i.e., who had an accurate mental picture to guide them -- would do better on the transfer test. The characteristics of the next problem coming up in the transfer test were not predictable from regularities in problem sequencing yet each new problem must be "sized-up" extremely rapidly and performance must be extremely fluent if successful Sparrow and Sidewinder attacks are to be made in the short time available at the increased transfer speed of 500 knots.

Figure 4 summarizes the differences in the instructional sequences for the two groups used in the experiment.

Figure 5 summarizes scoring and transitioning criteria used throughout the instructional sequence.

EXPERIMENTAL GROUP (ENHANCED TRAINER)

1. THREE ENHANCED FREE-FLY PROBLEMS: ONE AT EACH TARGET ASPECT (TA), 220 KNOTS

2. PRACTICE IN STATIC MODE WITH TRIANGLE: DO TWO OF EACH TA IN SUCCESSION, EACH WITHIN 60 SEC., NO ERRORS

3. PRACTICE IN STATIC MODE: SAME TRANSITION CRITERIA AS ABOVE, STATIC TRIANGLE ONLY AFTER ERROR

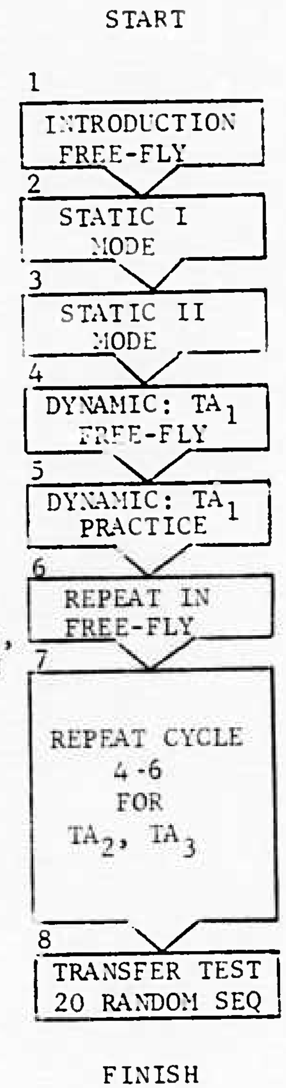
4. SAMPLE ENHANCED FREE-FLY PROBLEM AT TA_1

5. PRACTICE IN DYNAMIC MODE AT TA_1, ON-DEMAND GRAPHICS AVAILABLE. DYNAMIC TRIANGLE AFTER ERROR. DO TWO CORRECT IN SUCCESSION: EACH WITH NO ERRORS, SIDEWINDER PHIT ≥ .80; ABOVE 300 KNOTS, ALSO SPARROW PHIT ≥ .50, TO TRANSITION TO NEXT SPEED LEVEL

6. EACH INCORRECT PROBLEM REPEATED IN ENHANCED FREE-FLY MODE

7. SAME PROCEDURE AS ABOVE FOLLOWED FOR TA_2, TA_3

8. TWENTY LOW, MEDIUM, HIGH TA PROBLEMS: NO GRAPHICS AVAILABLE EXCEPT MISSILE FIRE DISPLAYS



CONTROL GROUP (REDUCED TRAINER)

1. SAME, EXCEPT FREE-FLY STRIPPED OF GRAPHIC TRIANGLE, OPTIMAL PATH, AND BOGEY TRACK

2. SAME AS E-GROUP EXCEPT NO TRIANGLE DISPLAYED

3. SAME AS E-GROUP EXCEPT NO TRIANGLE AFTER ERROR

4. STRIPPED FREE-FLY WITH SAME PROBLEM AT TA_1

5. PRACTICE IN DYNAMIC MODE AT TA_1; NO TRIANGLE AFTER ERROR; ON-DEMAND GRAPHICS UNAVAILABLE: SAME TRANSITIONING CRITERIA AS E-GROUP

6. EACH INCORRECT PROBLEM REPEATED IN STRIPPED FREE-FLY MODE

7. SAME PROCEDURE AS ABOVE FOLLOWED FOR TA_2, TA_3

8. SAME AS E-GROUP

Figure 4. Experimental and Control Groups Instructional Sequences Dynamic-Mode Cycle Repeated for Each of Seven Speed Levels

1. <u>STATIC PROBLEM SCORING CRITERIA</u>:
   No errors
   No help key
   Latency 60 sec

2. <u>Transition to next target aspect</u>:
   Two successive static problems correct

3. <u>Transition from static to dynamic mode</u>:
   Transition through three successive target aspects

4. <u>DYNAMIC PROBLEM SCORING CRITERIA</u>:
   *Meet static problem criteria and
   **SPARROW pHit $>$ .50 and SIDEWINDER pHit $>$ .80

5. <u>Transition to next target aspect</u>:
   Two successive dynamic problems correct

6. <u>Transition to next speed level</u>:
   Transition through 3 successive TA's

7. <u>Transition from practice to test mode</u>:
   Transition through 7 successive speed levels (220 - 460)

*else, take next dynamic problem
**else, repeat same problem in free-fly mode

Figure 5. Scoring and Transitioning Criteria

SECTION III

DATA COLLECTION, DATA ANALYSES, AND DISCUSSION

DATA COLLECTION

The details of the procedures that were used in this and the earlier field trial were described in an earlier report in this series.[1] Initial storage limitations (8K of core), and the requirement for inexpensive recording devices with relatively high reliability determined the use of these procedures. During the time these field trials were being run, inexpensive floppy disk systems became available. These have been integrated with other interfacing hardware, so that all data recording and storage will be done in the future on floppy disks.

The data-collection was managed by a Navy Training Device Technician. In general, this was a feasible arrangement. The data were received from the field in the form of punched paper tapes. While each student was practicing with the trainer, a record of his performance was punched by a teletype (with a silencer) attached to the terminal. The greatest disadvantage of this procedure is the time required to process tapes and to produce summary statistics.

Values of the following dependent variables, with the exception of frequency of use of on-demand keys, were recorded for both groups, both in practice and in transfer test sessions:

TABLE 2. DEPENDENT VARIABLE LIST

COUNTERS	STATIC VARIABLES	DYNAMIC VARIABLES
PROBLEM NUMBER	TOTEBOARD TOTAL LATENCY	LATENCY TO CC INPUT
STATIC ATTEMPTS	TOTEBOARD TOTAL ERRORS	LATENCY TO FIRE, SP & SW
STATIC COMPLETIONS	USE OF TRIANGLE KEY*	NUMBER OF TURNS
DYNAMIC ATTEMPTS		HIT PROBABILITY, SW
DYNAMIC COMPLETIONS		HIT PROBABILITY, SP
STATIC ABORTS		LEAD COLLISION ANGLE ERROR, SP
DYNAMIC ABORTS		USE OF TRIANGLE KEY*
		USE OF TOTEBOARD KEY*
		INFLIGHT CHECKLIST

*Experimental group only. In addition, an attitude questionnaire and comment sheet was completed by each student at the end of the session with the trainer.

[1]Rigney, et al., 1973.

DATA ANALYSES

The values of the above variables were used in the analyses. Intermediate summaries consisting of sums, sums of squares, and N's were listed by the statistical program for visual inspection. Subsequent analyses were done manually, using appropriate categories of these data. This method of summary and analysis is feasible with relatively small samples (29 and 31) and has the advantage of allowing visual inspection of intermediate-level summaries to check for errors and to identify additional ways to organize the data.

Hard copy listings of the intermediate summaries, for each student, for each class, and for each of the two groups in the field trial were made, and are available for inspection. However, in the interests of saving space, all of these data will not be reproduced here.

TRANSFER TEST ANALYSES. It will be recalled that the end-of-course transfer test was designed to present the students in each of the two groups with an unpredictable mixture of (20) air intercept problems, at a greater difficulty level, as determined by 40 knots higher speed (500 knots). The objective was to test the students' ability to cope with unexpected variations in initial problem conditions: initial positions, headings and ranges of the bogey; and widely varying initial target aspects between bogey and fighter. All students took the same twenty problems, but in different random orders.

It is clear from the data in table 3 that the enhanced group did very slightly better (not statistically significant) on number of problems correct out of 20, and on both missile (Sparrow and Sidewinder) scores. Some explanation of the variables listed in table 3 is in order.

"Static problems"refers to the first part of an intercept problem in which the student must mentally compute values of six variables for the intercept "triangle." He must do this within 60 seconds and without error for the problem to be scored correct. In the transfer test, the student had to go on and complete the intercept even though he might not achieve these criteria. If he made an error in arithmetic, the remainder of the intercept was scored incorrect. If he made no errors, but did not finish his computations within 60 seconds, the "static problem" was scored incorrect, but he could go on to achieve a correct score on the subsequent (dynamic) part of the problem. There, a pHit score ≥ .50 was required for the Sparrow missile at all speed levels above 300 knots, and a pHit score for the Sidewinder missile ≥ .80 at all speed levels, for the subsequent part of the problem to be scored correct. The two missile firing scores were set at different cutoffs because of the differences in relative difficulty, as judged by an experienced aviator, in making these attacks. For example, due to the high closing rate of the Sparrow attack approach tactic, there is only a very small "window" for the student to fire through (see figures 1 and 2).

Latencies to finish certain parts of the problem were recorded in seconds. Number of turns included the turn to collision course and all

TABLE 3. GROUP COMPARISONS ON TRANSFER TEST DATA
(20 PROBLEMS)

VARIABLES	ENHANCED (N=31) MEAN	ENHANCED (N=31) SD	REDUCED (N=29) MEAN	REDUCED (N=29) SD	t	p	% VARIANCE (ω^2) S*	% VARIANCE (ω^2) P*
1. STATIC PROBLEMS # CORRECT	15.93	2.46	15.48	2.04	.768	.4454	1.0	0.0
2. DYNAMIC PROBLEMS # CORRECT	10.09	2.72	9.34	3.55	.922	.3603	1.4	0.0
3. LATENCY (SEC.) TO COMPUTE TOTEBOARD VALUES	30.2	22.42	29.08	13.84	.23[illegible]	.8182	.1	0.0
4. LATENCY (SEC.) TO FIRE SPARROW	65.96	16.66	66.26	16.80	.069	.9449	0	0.0
5. LATENCY (SEC.) TO FIRE SIDEWINDER	130.47	25.98	128.09	20.59	.391	.6169	.3	0.0
6. NUMBER OF TURNS	5.13	1.43	4.98	1.32	.421	.6751	.3	0.0
7. SPARROW P-HIT SCORE	57.97	40.21	54.52	41.70	.326	.7454	.2	0.0
8. SIDEWINDER P-HIT SCORE	94.09	19.98	90.86	26.20	.539	.5919	.5	0.0

*S = Sample, P = Population (ω^2: see Hays, 1963) subsequent turns. The requirement to fire a Sparrow at speed levels from 300 knots up added to the number of necessary turns.

PRACTICE SESSION DATA ANALYSES. The sequencing logic for the practice problems was described in figure 4. Basically, students in both groups had to continue practicing until they achieved the transitioning criteria for that mode (Static of Dynamic) or (speed) level. They then were automatically transitioned to the next mode or level. As explained above, the "enhanced group" was exposed to several graphic instructional aids during introductory sample problems, the first stage of the static mode, when they made computational errors, and while they were repeating entire intercept problems that they did not "pass" the first time and any other time on demand. Analyses of data recorded during the practice sessions are summarized in tables 4-12.

Frequencies of various events are summarized in table 4. Some of the variables require some explanation. Again, number of static problems correct refers to computations of the values for the six triangle variables in both the special static mode and in the subsequent dynamic mode. Number of dynamic problems attempted includes the last part of all problems after the static mode. Proportion of problems repeated refers to the fact that, if scoring criteria were not achieved on the dynamic part of a problem, that problem was automatically presented in the free-fly mode. For students using the reduced trainer, this meant flying the problem again without having to compute intercept triangle variables, but with none of the other graphic aids. For students using the enhanced trainer, the problem was repeated, too. But in this case, the dynamic triangle, the optimal path, and the bogey track history were present throughout the problem. Proportion of problems aborted refers to those cases in which a student was interrupted during a problem, or he hit the missile firing key before 64 seconds into the problem.

It is noteworthy that students in both groups aborted a much higher proportion of repeated problems (.12 and .10) than they did new problems (.03 and .02). Recall that the students knew they were not being scored on repeated problems, which were in the free-fly mode. Evidently they often felt that they had extracted enough information at some point in the repetition and decided to terminate the practice, or they did not want to repeat the problems at all.

It is apparent from the data in table 4 that the students using the reduced trainer took fewer practice problems and achieved final transitioning criteria in fewer on-line sessions than was the case for students in the other group.

Also, students in the enhanced group generally did slightly worse than the other group in terms of proportions of problems attempted that met scoring criteria, i.e., that were scored as correct. It should be recalled that the transitioning criteria added to the scoring criteria the requirement to successfully complete <u>two</u> problems in succession in order to transition to the next speed level, or at the end, to transition to the

TABLE 4. GROUP COMPARISONS ON PRACTICE SESSION DATA: FREQUENCY VARIABLES

FREQUENCY OF EVENTS	ENHANCED (N=31) MEAN	SD	REDUCED (N=29) MEAN	SD	t	p	% VARIANCE (ω^2) S*	P*
1. NUMBER OF ON-LINE SESSIONS	11.47	4.07	8.65	2.66	3.196	.0026	16.4	14.6
2. TOTAL NUMBER OF PROBLEMS ATTEMPTED	154.61	37.27	126.27	34.06	3.067	.0033	14.0	12.3
3. NUMBER OF STATIC PROBLEMS CORRECT	103.45	19.53	89.37	20.11	2.746	.0080	11.5	9.8
4. NUMBER OF DYNAMIC PROBLEMS ATTEMPTED	117.32	28.91	97.14	29.91	2.657	.0102	10.9	9.2
5. NUMBER OF DYNAMIC PROBLEMS CORRECT	57.77	6.72	54.34	9.28	1.630	.1160	5.0	3.0
6. PROPORTION STATIC ATTEMPTS CORRECT	.67		.71					
7. PROPORTION DYNAMIC ATTEMPTS CORRECT	.48		.55					
8. PROPORTION DYNAMIC PROBLEMS REPEATED IN FREE FLY	.27		.24					
9. PROPORTION REPEATED (FF) PROBLEMS ABORTED	.12		.10					
10. PROPORTION DYNAMIC PROBLEMS ABORTED	.03		.02					

*S = Sample, P = Population, (ω^2: see Hays, 1963)

transfer test. In table 4, number of problems correct is based on scoring criteria. It will be seen later, in table 12, that students in the enhanced group had a slightly higher error rate on the toteboard, throughout all practice conditions. If a student made a toteboard error during the dynamic phase of practice (220 through 460 kt), he was allowed to finish the intercept, and his turns and missile firing scores were included in the data. But, the problem was counted as incorrect. Under these conditions, the higher toteboard error rate of the enhanced group could have required this group to attempt more problems, even though their proficiency scores, turns and missile pHit scores were as good as the other group's.

The comparative analyses of elapsed times for various events are summarized in table 5.

The various response latencies; to complete the toteboard (mentally compute six values for the intercept triangle), to fire the Sparrow, and to fire the Sidewinder, are elapsed times, in seconds, from the beginning of a problem until a student achieved these conditions.

These latencies are means computed over all problems, over the static and dynamic modes, and over all seven speed levels. Thus, they might be regarded as summary fluency scores for each group.

It is apparent, from the data in table 5, that the enhanced group required an average of 2.15 hours longer to achieve final transitioning criteria (460 knot level) than did the reduced group (12.51 hours vs 10.36 hours). Means and standard deviations of these values in hours are total elapsed times students spent on the trainers, as recorded manually in a log. Thus, these times are not as accurate as those in remainder of the table, which were automatically recorded in minutes, or seconds, by the computer program. Differences between response latencies to complete major parts of a problem were very small, with the reduced group being a few seconds quicker, over all.

The summary statistics in table 6 are overall values of various indicators of accuracy of performance. The probability of hit scores for firing the two missiles have been described above. The algorithms for computing these scores take basic parameters into account, as diagrammed in figure 2. Because firing the Sparrow accurately is a much more difficult problem for the student RIO than firing the Sidewinder, the cutoff score was set much lower (Sparrow, pHit = .50; Sidewinder, pHit = .80).

The lead collision course error refers to the error in leading the bogey when "aiming" the Sparrow. The absolute error is presented in the table. Leading too much or too little is not differentiated here, although it could be of tutorial importance to do so.

Number of turns during intercept, like all the measures in these tables, is a summary mean over all speed levels and target aspect angles. It is a measure of the precision with which the student could "fly" the interceptor under all these varying conditions. It includes the initial turn to collision course, and in this respect differs from the measures of the same variable reported for the earlier field trial of this trainer.

TABLE 5. GROUP COMPARISONS ON PRACTICE SESSION DATA: TIME VARIABLES

RESPONSE LATENCIES AND OTHER EVENT TIMES	ENHANCED (N=31)		REDUCED (N=29)				% VARIANCE (ω^2)	
	MEAN	SD	MEAN	SD	t	p	S*	P*
1. TOTAL TIME SPENT ON TRAINER (HRS) (INCL. TEST)	12.51	3.12	10.36	2.68	2.854	.0060	12.3	10.6
2. TIME PRACTICING NEW PROBLEMS (MIN)	480	111.53	394	102.08	3.109	.0029	14.3	12.6
3. LATENCY TO COMPLETE TOTEBOARD (SEC)	44	32.07	41	25.34	.400	.6905	.3	0
4. LATENCY TO FIRE SPARROW (SEC)	105	24.34	102	21.88	.501	.6134	.4	0
5. LATENCY TO FIRE SIDEWINDER (SEC)	205	59.95	201	56.53	.265	.7916	.1	0

*S = Sample, P = Population, (ω^2: see Hays, 1963)

TABLE 6. GROUP COMPARISONS ON PRACTICE SESSION DATA: MISSILE FIRING AND OTHER ACCURACY MEASURES

ACCURACY SCORES AND MEASURES	ENHANCED (N=31) MEAN	SD	REDUCED (N=29) MEAN	SD	t	p	% VARIANCE (ω^2) S*	P*
1. SPARROW FIRE: P-HIT SCORE	60.89	38.49	62.70	38.09	.183	.8555	0.1	0.0
2. SPARROW LEAD COLLISION COURSE ERROR (DEGREES)	4.05	8.92	3.77	7.43	.132	.8957	0.0	0.0
3. SIDEWINDER FIRE: P-HIT SCORE	88.57	29.45	89.27	28.66	.093	.9261	0.0	0.0
4. NUMBER OF TURNS DURING INTERCEPT	5.70	1.76	5.87	2.00	.350	.7275	0.2	0.0
5. ERRORS IN COMPLETING TOTEBOARD	.57	1.32	.44	1.13	.408	.6844	0.3	0.0

*S = Sample, P = Population, (ω^2: see Hays, 1963)

Errors in completing the toteboard concerns the frequency of errors students made in computing and entering values of the six intercept "triangle" variables. The frequency of these errors did diminish with practice, but some students in both groups continued making an occasional error throughout the training. It was our experience in the earlier field trial that many of these errors were due to the inability to tell left from right instead of to computational failures.

The most obvious conclusion to be drawn from inspection of table 6 is that the two groups were very similar to each other in terms of these overall proficiency measures. The enhanced group did make more toteboard errors as indicated by the means. It will be seen that the distribution of these errors, shown later in table 12, is of importance for explaining the results.

TRENDS ACROSS SUCCESSIVE PRACTICE CONDITIONS

Strong evidence for the effectiveness of the trainer as a device for teaching basic skills was presented in the report of the first field trial.[1] Similar evidence is available from the current field evaluation. Pertinent tables are presented below. In all cases, the trends across the tables, from left to right, reveal the effects of practice, on low, medium, and high target aspect problems, driven by increasingly higher problem speeds, from 220 to 460 knots. In some cases, lower and upper bounds of response latencies are influenced by the speed of the problem. However, in the case of the mental computations of values of the six intercept triangle variables, it is always to the advantage of the student to get this mental chore done as quickly as possible, to avoid getting behind the problem.

Table 7 presents total latencies to complete the toteboard, for all the values of the six variables. As in the previous field evaluation, there was a marked reduction in means and variances between first and last practice conditions. Over all target aspect categories (bottom row), the mean latency was reduced by a factor of 2.30, the standard deviation by a factor of 3.22.

---

[1] Rigney, et al., 1973.

TABLE 7. OVERALL LATENCY (SEC) (MEANS AND VARIANCES) TO COMPLETE THE TOTEBOARD AS A CONSEQUENCE OF PRACTICE (N = 60)

TARGET ASPECT		STATIC I	STATIC II	DYNAMIC LEVELS: SPEED 220	260	300	340	380	420	460	ROW TOTAL
LOW	M	79.74	39.33	50.45	37.64	36.02	30.32	26.03	27.37	24.90	41.71
	SD	64.66	22.32	31.21	16.11	22.73	11.14	9.30	17.54	10.17	36.26
MED	M	61.32	51.22	49.33	44.34	37.32	32.88	36.18	32.52	28.33	41.64
	SD	32.71	26.60	28.34	18.76	17.80	12.30	18.25	15.94	9.40	23.77
HIGH	M	57.30	61.25	56.69	49.36	40.04	35.66	35.38	34.91	36.29	44.07
	SD	28.49	35.21	37.22	23.31	18.66	17.08	16.33	10.97	21.05	25.74
COLS TOT	M	67.96	51.29	52.16	44.12	37.54	33.10	33.14	31.98	29.51	42.49
	SD	49.00	30.14	32.45	20.34	20.32	14.02	16.07	14.94	15.22	29.39

The rise in this latency at the 220 knot level indicates the student's first experience with the B-scan and the requirement to keep up with the problem. The highest target aspect problems (second row from the bottom) evidently presented the most difficult computations, possibly because some of the numbers involved were larger.

We see similar trends in the data in table 8, where frequency of toteboard errors is summarized. Students tended to make more errors in high target-aspect problems.

Scores for firing missiles obviously would be influenced by increasing the speed of the intercept problem. It becomes more and more difficult for the student to get his aircraft into correct position for firing before it is too late. Nevertheless, the pilot scores for firing the Sparrow and the Sidewinder, as shown in tables 9 and 10, do indicate some improvement, in most cases, despite the increasing speeds.

TABLE 8. OVERALL ERRORS IN COMPLETING TOTEBOARD, ACROSS SUCCESSIVE PRACTICE CONDITIONS (N = 60)

TARGET ASPECT		STATIC I	STATIC II	DYNAMIC LEVELS: SPEED 220	260	300	340	380	420	460	ROW TOTAL
LOW	M	0.92	0.54	0.79	0.41	0.46	0.27	0.21	0.21	0.33	0.50
	SD	1.66	1.29	1.66	0.88	1.25	0.84	0.55	0.80	1.21	1.27
MED	M	0.83	0.56	0.55	0.54	0.44	0.26	0.59	0.35	0.31	0.50
	SD	1.37	1.04	1.15	1.00	1.04	0.72	1.77	1.20	0.83	1.19
HIGH	M	0.73	0.77	0.70	0.62	0.40	0.47	0.45	0.33	0.51	0.54
	SD	1.26	1.55	1.42	1.19	0.87	1.26	1.42	0.95	1.26	1.26
COL TOT	M	0.84	0.63	0.70	0.53	0.43	0.34	0.43	0.30	0.38	0.51
	SD	1.30	1.46	1.04	1.09	0.97	1.39	0.98	0.98	1.13	1.25

TABLE 9. TRENDS IN SPARROW P-HIT SCORES (MEANS AND VARIANCES) ACROSS SUCCESSIVE PRACTICE CONDITIONS, (N = 60)

TARGET ASPECT		DYNAMIC LEVELS: SPEED 220	260	300	340	380	420	460	ROW TOTAL
LOW	M			56.07	58.27	65.13	60.11	60.94	59.95
	SD			40.70	40.32	37.76	38.94	40.42	39.77
MED	M			69.98	68.57	63.91	61.79	71.09	66.96
	SD			33.85	32.90	36.38	36.99	31.96	34.63
HIGH	M			66.96	58.65	59.53	53.36	56.89	58.61
	SD			34.25	40.01	39.30	41.82	40.13	39.59
COL TOT	M			63.49	62.17	62.65	57.87	62.59	61.70
	SD			37.30	37.91	37.88	39.70	38.45	38.33

TABLE 10. TRENDS IN SIDEWINDER P-HIT SCORES (MEANS AND VARIANCES) ACROSS SUCCESSIVE PRACTICE CONDITIONS, (N = 60)

TARGET ASPECT		DYNAMIC LEVELS: SPEED 220	260	300	340	380	420	460	ROW TOTAL
LOW	M	74.17	88.22	88.13	90.13	90.63	87.35	88.33	85.90
	SD	40.68	29.99	30.16	28.33	26.99	31.03	29.45	32.40
MED	M	81.90	93.56	93.72	93.35	88.13	92.50	95.38	91.06
	SD	36.05	21.80	21.38	22.87	29.58	24.30	18.71	26.10
HIGH	M	86.48	89.35	94.75	91.91	84.34	92.13	91.57	89.90
	SD	31.21	29.10	18.90	25.24	34.88	25.26	24.72	27.93
COL TOT	M	79.90	90.46	91.69	91.91	87.28	90.82	91.33	88.88
	SD	37.16	27.16	24.96	25.37	31.23	26.89	25.44	29.12

It should be noted that students could fire the Sparrow below 300 knots, and a few did this, but to be consistent with operational procedures the program did not count these scores toward transitioning to the next level. P-Hit scores for firing the Sparrow decreased from 300 to 460 knots for the high target aspect problems, again an indication that this was the most difficult of the three target aspect categories.

The high target aspect category evidently was not markedly more difficult than the low and medium categories, in the case of the Sidewinder, despite the increasing speeds. There was a steady improvement in scores across the successive speed conditions.

The trends in number of turns are shown in table 11. The biggest improvement occurred for low target aspect problems. These low target aspect problems also were the first to occur at 220 knots in the instructional sequence. These trends corroborate the evidence in the preceding tables for the effectiveness of the trainer.

TABLE 11. MEANS AND VARIANCES FOR NUMBER OF TURNS USED TO MAKE AN INTERCEPT ACROSS SUCCESSIVE PRACTICE CONDITIONS (N = 60)

TARGET ASPECT		DYNAMIC LEVELS: SPEED 220	260	300	340	380	420	460	ROW TOTAL
LOW	M	7.02	5.86	5.65	6.22	6.14	6.06	5.82	6.15
	SD	3.10	1.94	2.03	1.64	1.40	1.69	1.45	2.11
MED	M	5.97	5.80	4.91	5.67	5.58	5.49	5.01	5.51
	SD	2.02	1.95	1.50	1.41	1.59	1.56	1.15	1.66
HIGH	M	5.77	5.28	5.26	5.72	5.89	5.77	5.54	5.63
	SD	2.17	1.71	1.38	1.62	1.86	1.52	1.72	1.73
COL TOT	M	6.37	5.63	5.33	5.85	5.85	5.78	5.50	5.77
	SD	2.63	1.88	1.73	1.57	1.67	1.59	1.51	1.87

COMPARISON OF TRENDS BETWEEN GROUPS

It is important to examine trends in each group, to identify any differences between groups that might be attributable to differences in treatment. Table 12 summarizes this information. There are very few differences between the two groups with respect to turns and pHit scores, in terms of trends across practice conditions. The enhanced group did attempt a few more problems in every practice condition, yet their scores on the above proficiency measures were approximately equivalent to the other group. These data also reveal noteworthy differences between the two groups in terms of computational errors in computing intercept triangle values, in the static mode and at most of the speed levels. The overall mean for the enhanced group was .57 (SD = 1.32) versus .44 (SD = 1.13) for the reduced group (Table 6). The significance of this is as follows. During the static phase, the display of the static triangle may have been distracting during the performance of mental arithmetic. During the dynamic phase of the practice, 220 through 460 knots, it will be recalled that students still had to compute intercept triangle values. Then, they went on to "fly" the intercept, in the second part of the problem. If they had made a computational error, they were allowed to finish the intercept, and their proficiency scores (number of turns, missile firing scores) were included in the data. However, the problem was <u>not</u> counted toward transitioning to the next TA category or next speed level. Nor, was the problem repeated in free fly, nor was it counted as correct. Therefore, this slightly higher error rate in the enhanced group could have been a major reason for this group having to do more practice problems and to take more time in the practice session, even though the proficiency scores of the two groups were almost identical at all practice stages.

The latencies to complete the toteboard, in table 12, also are noteworthy. The enhanced group was much slower in the first and second parts of the static phase; 74.25 sec vs 58.91 sec and 55.72 sec vs 46.01 sec. A possible explanation for this is again, that the geometric display of the static triangle was actually distracting, so far as the mental arithmetic task was concerned.

TABLE 12. COMPARISONS BETWEEN ENHANCED (E) AND REDUCED (R) GROUPS WITH RESPECT TO TRENDS IN SUCCESSIVE PRACTICE CONDITIONS (AVERAGED ACROSS TARGET ASPECT CATEGORIES)

NAME OF VARIABLE			STATIC		SPEED LEVELS: DYNAMIC PHASE						
			I	II	220	260	300	340	380	420	460
LATENCY TO DO TOTEBOARD	M	E	74.25	55.72	53.26	42.95	36.37	33.10	33.49	32.47	29.75
		R	58.91	46.01	50.21	45.81	39.08	33.10	32.61	31.53	29.21
	SD	E	53.52	33.98	34.02	21.82	18.91	14.91	17.63	12.33	14.28
		R	40.03	23.89	30.16	17.97	21.97	12.63	13.29	17.01	16.37
COMPUTATIONAL ERRORS IN TOTEBOARD	M	E	.93	.76	.73	.64	.47	.34	.49	.31	.39
		R	.71	.48	.67	.36	.38	.33	.34	.29	.37
	SD	E	1.35	1.51	1.38	1.19	1.08	1.08	1.66	1.02	1.28
		R	1.63	1.00	1.58	0.75	1.10	0.80	0.82	0.95	0.92
TOTAL NUMBER OF TURNS	M	E			6.15	5.60	5.25	5.86	5.80	5.71	5.4[illegible]
		R			6.64	5.68	5.42	5.82	5.93	5.84	5.64
	SD	E			2.34	1.78	1.55	1.63	1.66	1.53	1.40
		R			2.97	2.02	1.95	1.48	1.68	1.66	1.62
SPARROW PHIT SCORE	M	E					63.29	61.05	60.94	57.33	61.56
		R					63.74	63.66	65.12	58.38	63.83
	SD	E					37.16	38.04	38.46	39.94	38.97
		R					37.64	37.74	36.97	39.62	37.95
SIDEWINDER PHIT SCORE	M	E			79.87	89.12	92.08	91.83	86.10	91.40	91.28
		R			79.93	92.37	91.19	92.01	89.09	90.29	91.39
	SD	E			37.09	29.07	23.88	25.80	32.49	26.48	25.07
		R			37.32	24.16	26.35	24.80	29.17	27.35	26.00
STATIC PROBS			(MEAN NO. OF PROBLEMS PER STUDENT)								
ATTEMPTED[1]	M	E	20.93	12.80	19.06	13.97	18.13	18.32	20.29	15.45	15.64
		R	15.38	11.18	15.10	10.38	14.86	13.65	14.00	17.93	13.37
COMPLETED[2]	M	E	8.26	7.45	10.52	8.84	13.13	14.55	15.52	12.84	12.35
		R	8.27	7.48	8.76	7.07	11.10	10.69	10.96	14.65	10.37
DYNAMIC PROBS ATTEMPTED[3]	M	E			18.42	13.87	16.97	17.77	19.77	15.03	15.35
		R			14.89	10.31	14.07	13.45	13.86	17.45	13.10
COMPLETED[4]	M	E			8.58	7.94	7.90	8.10	9.16	8.23	7.87
		R			7.90	7.07	7.66	7.76	7.66	8.79	7.51

[1] Totals Attempted
E = 4793
R = 3662

[2] Totals Completed
E = 3207
R = 2595

[3] Totals Attempted
E = 3633
R = 2817

[4] Totals Completed
E = 1791
R = 1576

STUDENT ATTITUDE QUESTIONNAIRES

Essentially the same questionnaire was used in this study, as was used in the first field study, with the exception of several questions not applicable for the reduced group. The results of questions common to both groups are reproduced in table 13. It will be recalled that this was a forced-choice instrument with two positive, one neutral, and two negative categories for each item. There were ten items common to both groups. Since only 25 out of the 29 students in the reduced group responded to the questionnaire, versus all 31 students in the enhanced group, proportions instead of frequencies are given in the following tables (13, 14, and 15).

It is apparent from an examination of table 13 that both groups had generally favorable attitudes toward the trainer, as sampled by these questions. However, there were more extremes in attitudes among the reduced group. These differences are shown in table 14.

In addition to the items common to both groups, five items on the questionnaire were specific to the free-fly mode, in which the special graphics described above were available only to the enhanced group. The responses to these items are tabulated in table 15. In addition, one questionnaire item required a yes - no response:

"In free fly you could observe the relationships between intercept geometry and radar presentation during an intercept. Did you use this feature?" Of the 31 students, 25 responded yes and six responded no.

These data indicate a preponderance of favorable attitudes toward this feature of the trainer. (Kolmogorov-Smirnov one-sample test: $p < .01$).

The attitude questionnaires used with the two samples are reproduced in Appendix A.

BIOGRAPHICAL DATA

Certain items of background information were collected from the students. Although not all students supplied every item requested, scores on standardized tests and prior courses in the Navy were available from the Naval Aerospace Medical Research Laboratory, Pensacola. These data are summarized in tables 16 and 17. It is apparent that there were no significant differences in the data for the two groups.

INFLIGHT CHECKLIST DATA

The checklist devised for use by instructors during field testing of Model I was revised to make it simpler for the instructors to use. A copy is reproduced in Appendix B. The data from these checklists, which were used eleven times on each student, five during initial flight training (RT-8) and six during more advanced flight training (RT-13), were converted

TABLE 13. ANALYSIS OF STUDENT ATTITUDES TOWARD THE TRAINER
(CELL VALUES ARE PROPORTIONS OF N)
ENHANCED GROUP: N = 31

RESPONSE CATEGORY	ITEM NUMBER 1	2	3	4	5	6	7	8	9	16	MEANS
VERY FAVORABLE	.13	.13	.06	0	.23	.03	.29	.13	.29	.06	.135
FAVORABLE	.42	.58	.52	.16	.35	.29	.35	.52	.42	.19	.380
NEUTRAL	.35	.26	.35	.52	.29	.52	.13	.35	.19	.65	.361
UNFAVORABLE	.06	.00	.03	.26	.10	.13	.16	.00	.10	.06	.090
VERY UNFAVORABLE	.03	.03	.03	.06	.00	.03	.06	.00	.00	.03	.027

REDUCED GROUP: N = 25

RESPONSE CATEGORY	ITEM NUMBER 1	2	3	4	5	6	7	8	9	16	MEANS
VERY UNFAVORABLE	.12	.12	.28	.08	.40	.08	.32	.08	.20	.00	.168
FAVORABLE	.52	.52	.40	.20	.36	.20	.28	.68	.52	.28	.396
NEUTRAL	.24	.24	.24	.20	.24	.48	.08	.16	.16	.52	.256
UNFAVORABLE	.12	.12	.08	.52	.24	.24	.24	.08	.12	.20	.196
VERY UNFAVORABLE	00	00	00	00	00	00	00	.08	00	00	.080

(Kolmogorov-Smirnov One Sample Test of Means: $p = < .01$)

TABLE 14. DIFFERENCES IN MEANS OF PROPORTIONS OF SAMPLES EXPRESSING ATTITUDES TOWARD THE TRAINER

	VF	F	N	U	VU
ENHANCED GROUP	.135	.380	.361	.090	.027
REDUCED GROUP	.168	.396	.256	.196	.080
DIFFERENCES	-.033	-.016	+.105	-.106	-.053

TABLE 15. ATTITUDES OF STUDENTS TOWARD THE FREE FLY MODE IN THE TRAINER (CELL VALUES ARE PROPORTIONS OF SAMPLE) (N = 31)

RESPONSE CATEGORY	ITEM NUMBER 10	12	13	14	15	MEANS
VERY FAVORABLE	.35	.29	.23	.23	.13	.246
FAVORABLE	.42	.45	.32	.52	.32	.406
NEUTRAL	.19	.19	.39	.16	.45	.276
UNFAVORABLE	.03	.03	.03	.03	.10	.044
VERY UNFAVORABLE	.00	.03	.03	.06	.00	.024

(Kolmogorov-Smirnov One-Sample Test of Means: $p = < .01$)

TABLE 16. BIOGRAPHICAL DATA FOR THE GROUP USING THE ENHANCED TRAINER: APTITUDE TESTS AND PRECEDING NAVAL TRAINING COURSE SCORES
N = 32

STUDENT NUMBERS	AFQT	FAR	VT-10 ACADEMIC	VT-10 PRACTICAL
1				
1	6	7	47.82	3.05
2	6	9	53.40	3.13
3	5	3	50.10	3.00
4	8	5	61.76	3.27
5	5	3	57.48	3.00
6	5	7	49.50	3.06
7	6	5	52.12	3.03
8	5	4	45.14	2.99
9	8	8	61.10	3.19
10	4	1	42.38	2.96
11	5	4	48.28	3.03
12	7	9	53.82	3.07
13	6	3	59.24	3.17
14	7	5	44.14	3.11
15	5	4	55.84	3.04
16	5	5	58.50	2.96
17	5	5	49.52	3.00
18	6	1	58.94	3.26
19	7	7	43.48	3.07
20	4	7	51.08	3.11
21	5	4	51.96	3.04
22	7	8	52.80	3.08
23	5	8	54.64	3.17
24	5	4	52.70	3.05
25	5	6	40.58	3.08
26	8	7	62.44	3.33
27	4	3	42.76	3.08
28	7	6	51.10	3.01
29	7	8	49.89	3.06
30	6	6	56.28	3.20
31	4	2	46.00	3.11
32	6	5	52.56	2.91
MEAN	5.75	5.28	51.79	3.08
SD	1.19	2.20	5.91	.09
SE	.21	.39	1.05	.02

TABLE 17. BIOGRAPHICAL DATA FOR THE GROUP USING THE REDUCED TRAINER: APTITUDE TEST AND PRECEDING NAVAL TRAINING COURSE SCORES
N = 29

STUDENT NUMBERS	AFQT	FAR	VT-10 ACADEMIC	VT-10 PRACTICAL
1	4	4	51.04	3.02
2	4	1	48.80	3.12
3	6	5	51.00	3.51
4	5	4	42.66	2.90
5	7	7	52.24	3.26
6	6	5	50.10	3.00
7	8	9	49.56	3.06
8	9	9	63.16	3.35
9	3	9	48.98	3.08
10	8	6	59.86	3.21
11	4	6	52.64	2.99
12	8	5	51.06	3.08
13	8	4	59.44	3.17
14	8	8	53.60	2.97
15	6	7	49.58	3.10
16	5	6	53.42	3.18
17	5	4	50.88	2.97
18	4	8	58.68	3.23
19	8	4	48.28	3.09
20	8	9	60.46	3.36
21	7	2	41.78	3.07
22	7	8	57.70	3.20
23	8	9	50.28	3.07
24	5	1	45.74	3.04
25	6	7	55.46	3.16
26	7	5	50.40	3.05
27	7	9	41.44	3.00
28	7	7	49.54	3.04
29	6	5	54.20	3.02
MEAN	6.34	5.97	51.79	3.11
SD	1.61	2.40	5.40	.13
SE	.30	.45	1.00	.02

to ranks for the Mann-Whitney U test. Ranks and results of comparisons between the two groups are presented in table 18. The tests of significance indicate that the group that had used the enhanced trainer did slightly better in these two inflight phases ($p = .1423$ and $.0901$). Although their practice on the trainer could have contributed to this better showing; again, intersession differences in experience, and the relative unreliability of the checklist must be taken into account in such an interpretation.

SUMMARY OF RESULTS

1. The two groups did equally well on the end-of-course transfer test. The enhanced group was rated slightly higher on the inflight checklist for both of two flight training phases (table 3) (table 18).

2. The group using the enhanced trainer required more practice problems, took more time, and used more on-line sessions to reach the final transitioning criteria at 460 knots. These differences were statistically significant ($p < .01$), but the measures of association (ω^2) between independent and dependent variables were relatively low (tables 4 and 5).

3. Although the difference between means (20.18) of number of dynamic problems attempted (variable 4, table 4) was significant, ($p = .0102$), the difference between means of number of dynamic problems correct was only 3.43 ($p = .116$) (variable 5, table 4).

4. On practice problems the two groups' scores; response latencies, missile firing scores, number of turns, and computational errors, were not statistically significantly different (tables 5 and 6).

5. Practice with the two versions of the trainer resulted in marked improvement in fluency (as measured by response latencies) and proficiency (as measured by missile firing scores and number of turns) in both groups (tables 7, 8, 9, 10, and 11).

6. There were differences between the two groups in trends in accuracy measures across the successive levels (table 12).

7. The attitudes of the two groups toward the two versions of the trainer were in the favorable direction ($p < .01$) (table 13).

8. The group using the enhanced version of the trainer expressed favorable attitudes toward the special graphics features that were specific to that trainer ($p < .01$) (table 15).

9. There were no differences between the backgrounds of the two random groups with respect to prior test scores (tables 16 and 17).

TABLE 18. COMPARISON OF RANKED SCORES OF THE ENHANCED AND REDUCED GROUPS ON THE INFLIGHT CHECKLIST FOR TWO INFLIGHT TRAINING PHASES

STUDENT NUMBER	RT-8 (R) RANK SCORE	RT-8 (E) RANK SCORE	RT-13 (R) RANK SCORE	RT-13 (E) RANK SCORE
1	7.0	37.5	10.0	33.5
2	37.5	49.5	33.5	55.5
3	26.0	30.5	16.5	13.0
4	22.0	41.0	21.0	16.5
5	19.0	--	18.5	--
6	30.5	56.5	26.5	50.5
7	26.0	49.5	44.0	44.0
8	54.0	16.0	52.5	21.0
9	16.0	23.0	12.0	7.0
10	5.5	49.5	55.5	8.0
11	9.0	26.0	14.5	23.5
12	--	5.5	--	4.0
13	41.0	19.0	2.0	18.5
14	12.0	41.0	11.0	44.0
15	34.5	4.0	37.5	40.0
16	41.0	19.0	44.0	1.0
17	30.5	30.5	44.0	5.5
18	44.5	51.0	48.0	9.0
19	51.0	34.5	37.5	21.0
20	54.0	44.5	40.0	40.0
21	12.0	34.5	55.5	55.5
22	12.0	--	52.5	--
23	51.0	8.0	48.0	33.5
24	14.0	41.0	33.5	29.5
25	51.0	16.0	48.0	26.5
26	1.0	56.5	5.5	33.5
27	21.0	49.5	3.0	29.5
28	3.0	2.0	23.5	26.5
29	26.0	--	14.5	--
30		10.0		44.0
31		26.0		26.5
32		34.5		50.5

$z \cong 1.07$; $p = .1423$ $z \cong 1.34$; $p = .0901$

Scores computed with corrections for ties:
Mann-Whitney U test (one-tailed)

Scores were averages of checklist data for five flights (RT-8) and six flights (RT-13) per student.
Blanks indicate four students who were dropped from the course after completing the RT-13 phase. These data were not included in the statistical tests.

DISCUSSION OF RESULTS

A fundamental problem here is that it is not possible, in field environments, to control adequately temporal variables over the period of time that a student is going through school. Therefore, the practice session data collected over this period undoubtedly were affected by biases of one sort or another that must be taken into consideration when drawing conclusions from these data. The best data here, those from the end-of-practice transfer test, indicate that the experimental graphics had no observed effects on the final accuracy or fluency scores of the group that used them in comparison to the group that did not use them during practice. The two groups performed equally well on this transfer test. The data from the checklist used during the two phases of actual flight operations indicate that the students who used the enhanced version of the trainer did perform somewhat better in the air than the other group. These data covered a total of eleven practice flights per student.

Several post hoc, alternative explanations for the observed differences among groups in the practice session data, are possible, but further experimentation would be required to completely resolve the various issues that have been raised. These are presented in order of their power to explain the data.

1. The enhanced group's higher error rate in computing values of the intercept triangle (Table 12) might account for the facts that this group required an average of 28 more problems and 2.8 more hours during practice. Recall that their proficiency scores (missile firing and number of turns) nevertheless essentially were equal in each practice condition, and that their latency scores to complete the toteboard were usually a second or more slower. Just one computational error in the dynamic phase of practice (220 through 460 knots) would result in (1) that problem not being counted correct, (2) the student being allowed to finish the intercept, (3) his number of turns and missile pHit scores being included in the data, and (4) the problem not being repeated in free fly. Thu it appears that arithmeti accuracy was weighted too heavily in the scoring and the transitioning criteria. It is apparent that these errors did not prevent the enhanced group from making as good intercepts as the other group (Table 12).

2. The data in table 12 also suggest that the static triangle, as supplied continuously in static mode I, and after an error in static mode II, might have been distracting to the students in the enhanced group while they were performing mental arithmetic, since they required an average of 15.34 and 9.71 seconds longer, and their error rates were substantially higher, .93 versus .71 and .76 versus .48. This supports the first explanation above.

3. The bogey track history, optimal intercept path, and dynamic triangle were displayed to the experimental group during introductory problems, and also when problems were repeated in free-fly mode. Repeated problems constituted 24% to 27% of the total dynamic problems attempted for both groups. Therefore, this mode contained part of the treatment difference between the two groups. However, the effectiveness of repeating problems may have diminished during later stages of learning (practice for fluency).

4. In this field study, in which a major objective was to test the "survivability" of the trainer in a school environment, it was impossible to control all variables that might influence outcomes, in addition to the influence of the independent variables. For example, we learned that some of the students who were having unusual difficulties in grasping relationships between true and relative motion, or in learning to compute the values of intercept triangle variables, or in learning other basic intercept procedures, were given additional "after hours" practice on the trainer by the school. This was the school's prerogative, and, in fact, it indicates their confidence in the trainer. We can only assume the effects were random across groups. Also, it was not possible to schedule individual practice sessions on the trainer to rigorously control inter-session-intervals because flight schedules understandably had priority. The enhanced group may have had a less favorable intersession schedule from the standpoint of distractions, intersession forgetting, or for motivation to learn than the reduced group. If so, they could have required more time and taken more problems during practice.

5. A fifth possibility is that the group using the enhanced trainer actually came from a different population with respect to some correlate(s) of the dependent measures. Although there are very slight differences in the AFQT scores for the two groups, the scores from a preceding naval training course, VT-10, are essentially the same (Tables 16 and 17). In this regard, Stanley and Campbell have this to say about the posttest-only control group design:

> While the pretest is a concept keenly embedded in the thinking of research workers in education and psychology, it is not actually essential to true experimental designs. For psychological reasons it is difficult to give up "knowing for sure" that the experimental and control groups were "equal" before the differential experimental treatment. Nonetheless, the most adequate all-purpose assurance of lack of initial biases between groups is randomization. Within the limits of confidence stated by the tests of significance, randomization can suffice without the pretest. Actually, almost all of the agricultural experiments in the Fisher (1925, 1935) tradition are without pretest.[1]

Randomization procedures were taught to the TD technicians who monitored the operation of the trainer at the school. Each new class of students was to be divided into two random groups, using a table of random numbers and the standard randomization techniques.

---

[1]Campbell and Stanley, 1963, p. 25.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

1. The trainer described in this series of reports was designed to develop fluency in Radar Intercept Officers in performing basic procedures in air intercepts. The two sets of data from the field trials in the RIO school amply substantiate the assertion that the trainer did what it was designed to do. Some comparisons between this self-standing, CAI system in a terminal and the conventional radar trainers at the school are of interest:

2. The hardware cost of the Behavioral Technology Laboratories trainer was $24,000 versus approximately 10 times that for each radar trainer.

3. The BTL trainer automatically recorded objective measures of the performance of each student. The radar trainers had no provisions for doing this.

4. Modifications and extensions in the scope of the procedures taught by the trainer could be made relatively inexpensively by program changes. For example, differential altitudes and speeds, and radar operating procedures could be incorporated, thereby making the radar trainers unnecessary.

5. Although a technician-instructor was present to assist students while the trainer was in operation, further refinements in the data analysis programs would make this unnecessary. The trainer is essentially automatic. One instructor could monitor a room full of trainers. The radar trainers required a 1:1 instructor-student ratio for active learning.

6. The trainer incorporated error-correcting feedback and adaptive control sensitive to each student's entering skills. None of these features were in the radar trainers.

7. The hardware used for this trainer is general-purpose. It is only necessary to load a different program to teach a different course. With the addition of a floppy disk and IO interface, any one course from a library of courses could be loaded in a few seconds and detailed student records could be kept on cheap disks (approximately eight dollars) for as long as desired. Needless to say, the radar trainers lacked this flexibility or this capability.

8. The possible instructional effects of the bogey track history, optimal intercept path and dynamic geographic displays, evidently were masked (1) by distracting effects of displaying a static intercept triangle while students were performing mental arithmetic preparatory to initiating the dynamic phase of the problem, which may have caused the observed higher arithmetic error rates in the experimental group, and (2) by insufficient exposure of these instructional aids to the students in an error-

remediation loop.

9. However, it also is likely that these instructional aids, excluding the static triangle, would have been effective only in very early stages of practice for accuracy. In later stages of practice for fluency, external stimulus control over behavior is greatly reduced, for, by that time, the student has acquired mental representational structures capable of guiding his performance without external aids.

Recommendations

1. PSO CAI should be applied and tested in other areas of Navy training, using current off-the-shelf hardware, to fully develop the concept and to accumulate more information about CAI system variables.

2. A study should be undertaken to develop a design for a CAI-system-in-a terminal, based on what has been learned here, taking into account current and forseeable advances in electronics technology, instructional technology, and computer science. The appearance on the market of a hand-held stored-program computer, complete micro-processors on a .15 inch square silicon-on-sapphire LSI chip, and electronic watches with liquid crystal displays, are signs of the current revolution in electronics that will make this type of system feasible, attractive, and cost effective.

3. The results of the study reported here, relative to the effectiveness of special graphics, should not be generalized. The independent variable actually was a complex of fixed-effect variables; thus generalization is not statistically possible. It appears that it would have been better to schedule these graphics entirely in the front-loading rather than in the practice and remedial sections of the PSO CAI instructional strategy. There, a period of "free practice" on problems designed to teach the student how to extract the maximum instructional value from the graphics, and during which students were reinforced for using them, possibly would have been a more effective use of these instructional aids.

REFERENCES

Campbell, D. T., and Stanley, J. C. Experimental and Quasi-Experimental Designs for Research. Chicago: Rand McNally College Publishing Co., 1963.

Hays, W. L. Statistics for Psychologists. New York: Holt, Rinehart and Winston, 1963.

Rigney, J. W., Morrison, D. K., Williams, L. A., and Towne, D. M. Description and Initial Evaluation of a Computer-based Individual Trainer for the Radar Intercept Observer. Los Angeles: Behavioral Technology Laboratories (NAVTRAEQUIPCEN 71-C-0219-1), 1973.

Rigney, J. W., Morrison, D. K., Williams, L. A., and Towne, D. M. A Guide for the Application of Performance-Structure Oriented CAI in Naval Training. Los Angeles; Behavioral Technology Laboratories (NAVTRAEQUIPCEN 73-C-0065-1), 1974.

APPENDIX A

RIO STUDENT QUESTIONNAIRE - ENHANCED VERSION
N = 31

1. In comparison with other similar learning experiences, the recent experience with the intercept trainer was:

   a. Very enjoyable (4)
   b. Enjoyable (13)
   c. Neutral (11)
   d. Boring (2)
   e. Extremely boring (1)

2. As a method for teaching operating procedures, the intercept training system was:

   a. Very effective (4)
   b. Effective (18)
   c. Average (8)
   d. Ineffective (0)
   e. Very ineffective (1)

3. While using the intercept training system to learn operating procedures, I would have liked to have had the system answer for me:

   a. Very many questions (1)
   b. Many more questions (1)
   c. A few more questions (11)
   d. No more questions (16)
   e. No questions (2)

4. With the presence of an instructor and fully operating equipment I feel that intercept procedures would have been learned:

   a. In a much shorter period of training (2)
   b. In a shorter period of training (8)
   c. In about the same time (16)
   d. In a longer period of training (5)
   e. In a much longer period of training (0)

5. The intercept trainer is:

   a. Very easy to use (7)
   b. Easy to use (11)
   c. Neither easy or difficult to use (9)
   d. Difficult to use (3)
   e. Very difficult to use (0)

6. The initial instruction given on how to use the intercept trainer was:

   a. Much more than adequate to my needs (1)
   b. More than adequate to my needs (9)
   c. Adequate to my needs (16)
   d. Less than adequate to my needs (4)
   e. Much less than adequate to my needs (1)

7. About how long did it take you to learn to utilize the intercept trainer?

   a. More than two hours (2)
   b. About two hours (5)
   c. About 1-1/2 hours (4)
   d. About 1 hour (11)
   e. About 1/2 of the first hour (9)

8. The immediate knowledge of errors provided by the intercept trainer:

   a. Greatly aided learning RIO operating procedures (4)
   b. Aided learning (16)
   c. Made no difference in learning (11)
   d. Hindered learning (0)
   e. Greatly hindered learning (0)

9. Static mode requires that you perform necessary arithmetic computations without error in a specified time frame before continuing with intercepts. Did you find this:

   a. Very helpful in learning (9)
   b. Helpful in learning (13)
   c. Neutral (6)
   d. Of very little help (3)
   e. Of no help (0)

10. The intercept trainer repeats an intercept in Free Fly Display format where you did not achieve criterion firing position in the initial attempt. This allows you to review the intercept and perceive your errors. Did you:

   a. Strongly like this capability (11)
   b. Like this capability (13)
   c. Have no like or dislike for this capability (6)
   d. Dislike this capability (1)
   e. Strongly dislike this capability (0)

11. In Free Fly you could observe the relationships between intercept geometry and radar presentation during an intercept. Did you use this feature?

   a. Yes (25)
   b. No (6)

12. If you used Free Fly in the above way, do you believe it was:

    a. Very helpful in learning ([illegible]
    b. Helpful in learning ([illegible]4)
    c. Neutral (6)
    d. Of very little help (1)
    e. Of no help (1)

13. In Free Fly Mode, the Trainer provides an "optimal path" for the bogeys track down the scope, and a dotted "track history" of the bogey's actual path. As a method of associating intercept geometry with scope presentation these aids were:

    a. Very effective (7)
    b. Effective (10)
    c. Average (12)
    d. Ineffective (1)
    e. Very ineffective (1)

14. The trainer automatically provides a sample problem in Free Fly mode when advancing or changing problem category. This feature is:

    a. Very helpful (7)
    b. Helpful (16)
    c. Neutral (5)
    d. Of very little help (1)
    e. Of no help (2)

15. During the progress of any intercept you may display the intercept triangle by depressing the TRI key. When the triangle is displayed you will also see an "optimal path" and "track history" displayed on the "B" scope. In clarifying the problem solution, this aid was:

    a. Very effective (4)
    b. Effective (10)
    c. Neutral (14)
    d. Ineffective (3)
    e. Very ineffective (0)

16. The radar simulation provided by the intercept trainer was:

    a. Much more than adequate for learning basic intercept procedure (2)
    b. More than adequate for learning basic intercept procedures (6)
    c. Adequate for learning basic intercept procedures (20)
    d. Less than adequate for learning basic intercept procedures (2)
    e. Much less than adequate for learning basic intercept procedures (1)

17 Were there any particular intercept problems that were confusing?

RIO STUDENT QUESTIONNAIRE - REUDCED VERSION
N = 25

1. In comparison with other similar learning experiences, the recent experience with the intercept trainer was:

   a. Very enjoyable (3)
   b. Enjoyable (13)
   c. Neutral (6)
   d. Boring (3)
   e. Extremely boring (0)

2. As a method for teaching operating procedures, the intercept training system was:

   a. Very effective (3)
   b. Effective (13)
   c. Average (6)
   d. Ineffective (3)
   e. Very ineffective (0)

3. While using the intercept training system to learn operating procedures, I would have liked to have had the system answer for me:

   a. Very many questions (0)
   b. Many more questions (2)
   c. A few more questions (6)
   d. No more questions (10)
   e. No questions (7)

4. With the presence of an instructor and fully operating equipment I feel that intercept procedures would have been learned:

   a. In a much shorter period of training (0)
   b. In a shorter period of training (13)
   c. In about the same time (5)
   d. In a longer period of training (5)
   e. In a much longer period of training (2)

5. The intercept trainer is:

   a. Very easy to use (10)
   b. Easy to use (9)
   c. Neither easy or difficult to use (6)
   d. Difficult to use (0)
   e. Very difficult to use (0)

6. The initial instruction given on how to use the intercept trainer was:

   a. Much more than adequate to my needs (2)
   b. More than adequate to my needs (5)
   c. Adequate to my needs (12)
   d. Less than adequate to my needs (6)
   e. Much less than adequate to my needs (0)

7. About how long did it take you to learn to utilize the intercept trainer?

   a. More than two hours (2)
   b. About two hours (6)
   c. About 1-1/2 hours (2)
   d. About 1 hour (7)
   e. About 1/2 of the first hour (8)

8. The immediate knowledge of errors provided by the intercept trainer:

   a. Greatly aided learning RIO operating procedures (2)
   b. Aided learning (17)
   c. Made no difference in learning (4)
   d. Hindered learning (2)
   e. Greatly hindered learning (0)

9. Static mode requires that you perform necessary arithmetic computations without error in a specified time frame before continuing with intercepts. Did you find this:

   a. Very helpful in learning (5)
   b. Helpful in learning (13)
   c. Neutral (4)
   d. Of very little help (3)
   e. Of no help (0)

10. The intercept trainer repeats an intercept in Practice mode format where you did not achieve criterion firing position in the initial attempt. This allows you to review the intercept and perceive your errors. Did you:

   a. Strongly like this capability (5)
   b. Like this capability (13)
   c. Have no like or dislike for this capability (4)
   d. Dislike this capability (3)
   e. Strongly dislike this capability (0)

14. The trainer automatically provides a sample problem in Practice mode when advancing or changing problem category. This feature is:

a. Very helpful (6)
b. Helpful (14)
c. Neutral (5)
d. Of very little help (0)
e. Of no help (0)

16. The radar simulation provided by the intercept trainer was:

a. Much more than adequate for learning basic intercept procedure (0)
b. More than adequate for learning basic intercept procedures (7)
c. Adequate for learning basic intercept procedures (13)
d. Less than adequate for learning basic intercept procedures (5)
e. Much less than adequate for learning basic intercept procedures (0)

17. Were there any particular intercept problems that were confusing?

APPENDIX B

INFLIGHT CHECKLIST

NAME ____________________
CLASS ____________________
INSTRUCTOR ____________________

DATE ____________________
SPARROW WITH REATTACK
FLT CODE RT-13

INTERCEPT NUMBER	1	2	3	4	5	6
	N	N	N	N	N	N
1. Established acceptable collision heading						
2. Bogey on scope--aware of drift rate and direction						
3. Controls bogey drift by corrections to collision course						
4. Prior to Sparrow R max--breaks CC to establish LCC						
5. R max/R min OK--"passes dot" with good LCC						
6. After "fox 1"--displaced at proper range/time						
7. Achieved adequate displacement at start of counterturn						
8. Controls bogey drift while in early counterturn						
9. Achieved proper displacement at 90° DTG						
10. From beam position--maintained proper turn rate to control drift						
11. Approaching stern position--corrected turn rate to counter drift						
12. Rolled out within SW R max and turn rate limits						

INTERCEPT NUMBER	1	2	3	4	5	6
	N	N	N	N	N	N
THE STUDENT:						
1. Determined and turned to CC in an acceptable time span?						
2. Recognized and corrected drift in an acceptable time span?						
3. Anticipated arrival at pt. of turn for DD and gave turn directions on time?						
4. Anticipated arrival at counterturn pt. and gave turn directions on time?						
5. Remained "in step" with the problem so that he was not rushed?						
6. Appeared to have confidence in his decisions/problem evaluation?						
7. Interpreted B-scope indications correctly for Range and Angle Off?						
8. Provided sufficient amplifying commentary?						
9. Recognized and corrected errors in an acceptable time span?						
10. Avoided confusion and kept control of the problem if errors occurred?						

Do you have any amplifying comments that have not been covered?

INFLIGHT CHECKLIST

NAME ______________________ DATE ______________________

CLASS ______________________ SIDEWINDER ONLY

INSTRUCTOR ______________________ FLT CODE ______ RT-8 ______

INTERCEPT NUMBER	1	2	3	4	5
	N	N	N	N	N
1. Establishes acceptable collision heading					
2. Bogey on scope--aware of drift rate and direction					
3. Controls bogey drift by corrections to collision course					
4. Displaced at proper range/time					
5. Achieved adequate displacement at start of counterturn					
6. Controls bogey drift while in early counterturn					
7. Maintained proper displacement at 90° DTG					
8. From beam position--maintained proper turn rate to control drift					
9. Approaching stern position--corrected turn rate to counter drift					
10. Rolled out within SW R max and turn rate limits					

INTERCEPT NUMBER	1	2	3	4	5
	N	N	N	N	N
THE STUDENT:					
1. Determined and turned to <u>CC</u> in an acceptable time span?					
2. Recognized and corrected drift in an acceptable time span?					
3. Anticipated arrival at pt. of turn for <u>DD</u> and gave turn directions on time?					
4. Anticipated arrival at counterturn pt. and gave turn directions on time?					
5. Remained "in step" with the problem so that he was not rushed?					
6. Appeared to have confidence in his decisions/problem evaluation?					
7. Interpreted B-scope indications correctly for Range and Angle Off?					
8. Provided sufficient amplifying commentary?					
9. Recognized and corrected errors in an acceptable time span?					
10. Avoided confusion and kept control of the problem if errors occurred?					

Do you have any amplifying comments that have not been covered?