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BT33 TRAINING EFFECTIVENESS ANALYSIS

D. L. Finley and H. C. Strasel

ARI FIELD UNIT AT FORT BENNING, GEORGIA

U. S. Army
Research Institute for the Behavioral and Social Sciences

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The BT33 is a Swedish-built Forward Observer (FO) trainer for institutional use. This training effectiveness analysis of the BT33 was initiated to validate the concept that FO training devices could yield training and cost savings benefits. It was a part of and contributed to the cost and training effectiveness analysis being conducted on a FO trainer under development in the United States for the unit training environment.

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Item 20 (continued)

The results of the study determined that the FO training device concept is valid. All the tested training programs employing the BT33 resulted in training that appeared overall to be as good as or better than the current training program.

Of general research interest is the methodology developed to acquire student performance data on several indices and conditions and to evaluate and integrate these data into relative training effectiveness indices.

Research Report 1206

BT33 TRAINING EFFECTIVENESS ANALYSIS

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Systems Development and
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ARI Research Reports and Technical Papers are intended for sponsors of R&D tasks and other research and military agencies. Any findings ready for implementation at the time of publication are presented in the latter part of the Brief. Upon completion of a major phase of the task, formal recommendations for official action normally are conveyed to appropriate military agencies by briefing or Disposition Form.

FOREWORD

The research reported here was performed by the Army Research Institute's Fort Benning Field Unit. It is part of an ongoing program of research directed toward development of cost effective methods for individual and collective training. This program includes research on multiple aspects of the design, development, evaluation, and integration of cost and training effective training systems for the U.S. Army.

This report presents an analysis of the relative training effectiveness of the BT33, a Swedish-developed Forward Observer (FO) training device. The analysis was designed in response to a request by the USA Field Artillery School (USAFAS) and seconded by USA Training Support Center Training Devices Directorate (ATSC TDD). The study was to validate the concept that FO training devices could yield effective training with potential cost savings. Results of the study were to be used as input to the cost and training effectiveness analysis (CTEA) being conducted on the Observed Fire Trainer under development by the Army.

The research was executed at USAFAS using the FA Basic Officer Course as the vehicle. Close coordination between ARI and USAFAS, together with dedicated test supervision by the USAFAS Study Director, LTC Lyle Butler, Jr., and the Project Officer, CPT Spencer A. Fisher, resulted in a successful test of BT33 training effectiveness.

ARI research in training systems development is conducted as an inhouse effort augmented by contracts with organizations selected as having unique capabilities for research in the area. This study was performed by ARI personnel from the Fort Benning Field Unit. The project was conducted as part of Army Project 2Q763731A773, FY 76 Work Program, and Army Project 2Q763743A773, FY 77. It was directly responsive to the requirements of the USAFAS and ATSC TDD.

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BT33 TRAINING EFFECTIVENESS ANALYSIS

BRIEF

Requirement:

To validate the concept of Forward Observer (FO) training device cost and training benefits. This is in support of a program to develop a unit FO training device for the U.S. Army.

Procedure:

A Swedish institutional FO training device, the BT33, was obtained for testing at the U.S. Army Field Artillery School (USAFAS). It is similar in overall simulation capability to the Observed Fire Trainer (OFT) being developed in the United States for a more rugged unit training environment. FO performance resulting from the current FO training course (which employs costly live fire exercises) was compared to FO performances resulting from seven variations of the course using the BT33.

Findings:

The findings indicate that FO training devices like the BT33 can be effective additions to FO training programs. Specifically:

- The FO training device concept is valid. All the tested training programs employing the BT33 resulted in training that appeared overall to be as good as or better than the current training program.
- Most of the problems noted in the BT33 (e.g., poor target displays, poor maintainability design) are being dealt with in the OFT development.
- The most serious apparent limitation of the BT33, the two-dimensional display, as opposed to a three-dimensional display, is not a problem as long as it is realized that some time must still be allotted for additional visual skills development in the field environment.

Utilization of Findings:

The results of this BT33 training effectiveness analysis (TEA) are being integrated into the OFT cost and training effectiveness analysis (CTEA) and OT II test plans. These results are also being used by USAFAS, in conjunction with other data, to evaluate the possibility of retaining the BT33 at USAFAS for institutional training.

BT33 TRAINING EFFECTIVENESS ANALYSIS

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BT33 TRAINING EFFECTIVENESS ANALYSIS

Given the problems of increased ammunition costs and reduced training manpower and budget and the need for improved effectiveness, the USAFAS would like to develop these options: (a) achieve the present level of Forward Observer (FO) capability with much less manpower and budget; (b) achieve higher levels of FO capability within current manpower and budget limits; and (c) achieve some improvements in FO capability with somewhat less manpower and budget. Innovative training techniques which hold promise of providing these options are two very similar training devices: the Swedish SAAB-Scania Fire Control Simulator BT33 and the U.S.-developed Observed Fire Trainer (OFT). The BT33 is built for the institutional training environment and is currently available for analysis and evaluation. The OFT is now under development and will be suitable for both institutional and the more rugged unit environments. The question is, can these devices be integrated into unit and institutional FO training programs so as to provide the above options? This study is a part of the OFT Cost and Training Effectiveness Analysis (CTEA) program being conducted to answer this question.

OBJECTIVES

This Training Effectiveness Analysis (TEA) of the BT33 has been conducted to:

- Validate the concept of FO training device utility.
- Determine how such a device can be employed in the institutional environment so as to realize cost and training benefits.
- Provide data needed by the OFT CTEA study.
- Provide information useful to finalization of the OFT design.

METHOD

Quantitative data were obtained on the criterion performance of students trained under each of seven different experimental training programs employing the BT33. These data were compared to data on the performance of students trained under the current training program. The seven experimental training programs varied in the extent to which the BT33 was used in place of live fire and the particular event(s) for which it was substituted. The collection and comparison of these data provided a quantitative basis for evaluating the relative training

effectiveness of the BT33, used in alternative ways, as compared to the current training program.

Questionnaire data were also obtained from students, instructors, and BT33 operators. These data provided qualitative information regarding good and poor aspects of the BT33 and the acceptability of it to students and instructors for training and evaluation purposes.

SUMMARY CONCLUSIONS AND RECOMMENDATIONS

The results of this BT33 TEA study establish the following:

- The FO training device concept is valid. More specifically, all the tested training programs employing the BT33 resulted in training that appeared overall to be as good as or better than the current training program.

- Most of the problems noted in the BT33 (e.g., poor target displays, poor maintainability design) are being dealt with in the OFT development.

- The most serious apparent limitation of the BT33, the two-dimensional display, as opposed to a three-dimensional display, is not a problem as long as it is realized that some time must be allotted for additional visual skills development in the field environment.

These conclusions indicate that FO training devices (like the BT33) can be effective additions to FO training programs. The following recommendations are made:

- USAFAS should study the detailed results carefully for implications for maximizing the training effectiveness of such devices in training programs.

- When the BT33/OFT is used to a maximum extent, with simulation of several live-fire events, performance on the first actual live-fire exercise should be judged as a transitional shoot and evaluated accordingly.

TECHNICAL SUPPLEMENT

BACKGROUND

General

The Forward Observer (FO) is responsible for acquiring targets and directing artillery fire to suppress or destroy the target. The basic skills training of Artillery FOs is accomplished by both classroom instruction and live fire exercises. Currently, the major training devices (simulators) used in the U.S. Army Field Artillery School (USAFAS) 13-week Gunnery training programs are the "Puffboard" and the M-31 14.5mm subcaliber trainer. The "Puffboard" is a device which allows a puff of smoke to burst from a terrain mockup in response to a simulated round. The M-31 is a subcaliber device that allows FO training on 1/10 scale ranges. All other FO skills training takes place in the field and requires expensive ammunition and firing battery support.

Given the problems of reduced training manpower and budget, on the one hand, and the need for improved effectiveness, on the other hand, the USAFAS would like to develop these options: (a) achieve the present level of FO capability with much less manpower and budget, (b) achieve higher levels of FO capability within current manpower and budget limits, and (c) achieve some improvements in FO capability with somewhat less manpower and budget. Innovative training techniques which hold promise of providing these options are two very similar training devices: the Swedish SAAB-Scania Fire Control Simulator BT33 and the U.S.-developed Observed Fire Trainer (OFT). The BT33 is built for institutional training environments (like USAFAS) and is currently available for analysis and evaluation. The OFT is now under development and will be suitable for both institutional and unit environments. The question is, can these devices be integrated into unit and institutional FO training programs so as to provide the above options? This study is a part of the OFT CTEA program being conducted to answer this question.

Study Purposes

This BT33 TEA was designed to (a) validate the utility of the FO training device concept; (b) assess the relative effectiveness of the alternative ways the BT33 can be used in FO training at USAFAS; (c) provide preliminary data for input to the CTEA for the OFT; and (d) provide design and performance data on the BT33 device for consideration in development of the OFT. The study objectives and methodology developed to satisfy these purposes are described in the next major section.

System Descriptions and Potential Benefits

The BT33 fire control simulator consists of the following main parts: target area screen, central unit, display and burst projection units, and target display unit. The BT33 simulator is designed to be sited indoors. The battlefield panorama, including the target area, is projected on a screen by means of a slide projector. The observers can see the target area from their places in the lecture room as from observation posts. The instructor indicates the target or activities in the target area by means of the target display unit. The students observe the zone before them and use normal RTO communication procedures to make input to the device operator who simulates the Fire Direction Center (FDC). The device operator feeds data into the control panel of the central unit as necessary to implement student calls for fire. The positions of the bursts in the target area are calculated by the central unit. Burst positions simulated by symbols are projected in the target area by the burst projectors. The size and type of symbols are determined by the central unit to correspond to the specific call for fire of the student.

The OFT is quite similar in overall configuration and operation to the BT33. The main configuration difference (other than unitary construction and "ruggedizing" of the design) is that the students and the projection equipment are closer to the OFT target area display screen and, consequently, fewer students can be accommodated at one time. The principal operation difference is that certain OFT fire control functions have been automated, enabling the OFT instructor to perform both instructional and device operation roles (in the BT33, two persons are required to perform these roles). The principal display difference is that the OFT provides more realistic burst and target representations.

Potential training device benefits include the following:

- A better overall training effect by variations in artillery firing: impact burst, air burst, illumination missions, smoke, and firing against advancing tanks and ships. Variations are possible with respect to burst duration, angle of impact, firing direction, terrain scenes, dispersion, target movement and type, and number of firing guns. Experience gained from live firing at USAFAS is limited in number of guns used (often one platoon, two guns), the resemblance of terrain as compared to actual combat arenas, and the exclusive use of nonmoving targets.

- A shorter training time to achieve a fixed performance level.

- A work environment that is stimulating.

- Ability to continue training during bad weather.

- Economic gains by saving artillery ammunition, having fewer artillery and FDC support requirements, and having reduced instructor requirements for conducting live fire training.

- Added capability for training in night observation and fire adjustment.

METHODOLOGY

This study requires diagnostic as well as status information. In other words, the need is not only to determine if the BT33 is training effective but also to identify the conditions under which it is most effective and the factors determining effectiveness variation. This additional information can be used to maximize OFT effectiveness through inputs to system design and to training system procedures. Given this need for detailed information about both causes and effects, it was necessary to (a) obtain both student performance and subjective opinion data on a comprehensive measure set and (b) obtain criterion data on student performances resulting from alternative BT33/live fire mixes. The following two sections discuss the test design and analysis procedures used in the study.

Test Design

Design Considerations. The study design resulted from three considerations: (a) what are the alternative ways in which the BT33 could be integrated into the FO training program; (b) what constitutes the criterion conditions needed to demonstrate training effectiveness; and (c) how can the constitution of the various experimental groups be controlled with respect to aptitude levels? With regard to the first question, the BT33 and, hence, the OFT could be utilized in FO training at USAFAS for the following groups: Field Artillery Officer Basic Course (FAOBC) students, Field Artillery Officer Advanced Course (FAOAC) students, Marine Scout Officer Course (MASOC) students, Advanced Individual Training (AIT) students, and III Corps Artillery personnel. The FAOBC program provides the largest and most controllable population of beginning students and will yield the highest payoff if the training devices are proven useful. Therefore, the FAOBC program was selected as the test bed for the BT33 training effectiveness evaluation. The USAFAS Gunnery Department evaluated the FO portion of their FAOBC training program in terms of apparent BT33 capabilities and identified three points in the program at which the BT33 might well be substituted for current training procedures. These training events are

- The Puffboard Exercise--during Gunnery Week 2 the Puffboard is used to introduce the students to FO procedures and to provide the first opportunity for a few members of the class to practice. This device was described earlier.

- Daly Hill--a live-fire adjustment exercise taking place on Daly Hill, Fort Sill, during Gunnery Week 5. All students perform at least one mission.

- Arbuckle Hill--a live-fire exercise taking place on Arbuckle Hill, Fort Sill, during Gunnery Week 7. All students perform at least one mission.

Substitution of the BT33 for one or more of these events, plus the program as it is currently run, constitutes eight experimental conditions for the BT33 effectiveness evaluation. Experimental conditions 1 through 8 were as follows:

Training events	Experimental conditions							
	1	2	3	4	5	6	7	8
Puffboard	s*	x	x	s	s	x	s	x
Daly Hill	x	s	x	s	x	s	s	x
Arbuckle Hill	x	x	s	x	s	s	s	x

*s = BT33 substitution.

With regard to the second question, the criterion events are the three live fire graded exercises which follow the Arbuckle Hill training event.

- Mobile Shoot One--takes place during the 7th to 9th weeks of training and requires the students to walk or ride from shoot location to shoot location, using multiple target areas. All students perform at least one mission.

- Bunker Shoot--takes place during the 8th to 10th weeks of training and requires the students to work from a bunker and uses one target area. All students perform at least one mission.

- Mobile Shoot Two--takes place during the 9th to 11th weeks of training and, again, requires the students to walk or ride from shoot location to shoot location, using multiple target areas. All students perform at least one mission.

Performance data on these graded events, if comparable, would permit evaluation of the relative effectiveness of the alternative BT33 utilization plans.

A question that required examination was whether or not the data would be comparable. That is, would the sample of experiences of one experimental group on, for example, Mobile Shoot One, be reasonably similar to the sample of experiences encountered by other experimental groups, so that performance differences between the groups would be primarily a function of experimental condition differences. There were two factors affecting the comparability of the data. One factor was that no two students shoot at exactly the same target/terrain combination or from the same perspective. The other factor was that the mobile shoots take place alternately on two ranges which differ greatly in the difficulty of range estimation. With regard to the first factor, it was determined through discussions with the USAFAS Gunnery Department and a tour of range locations that, although the variety of perceptual problems that could be encountered was considerable, the sample of problems faced by any one experimental group would be reasonably equivalent to that faced by other groups. Further, the assignment of terrain/target situations to individuals could be considered to be essentially random. With regard to the second factor, the difference between the two ranges, it was determined that estimates of performance difference due to range difference could be computed and, hence, statistically accounted for.

With regard to the third question, control of group composition with respect to aptitude, USAFAS currently uses the STEP score[1] for this purpose. Their objective is to match student capabilities and requirements to instructional techniques. They do this by separating each class into four groups based on STEP scores--high, medium high, medium low, and low--which then receive separate instruction. For the BT33 effectiveness study, however, it was desired to compose groups of students with similar capability for each of the experimental conditions. The problem was to develop a way of classifying students which would both provide the instructors with easily managed groups of students in terms of instructional needs and still satisfy the requirements of the study. After much discussion a compromise was effected. Class groups were assigned to experimental conditions so that an equivalent sample from each of the four STEP-score categories was obtained for each experimental condition over all classes. Each instructor had representatives from only two of the categories (high-low or medium high-medium low) in each group. As a safety precaution, STEP scores were obtained for all students so that a covariance analysis could be conducted if necessary.

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[1]The STEP, or Sequential Tests of Educational Progress, score provides an overall index of spatial, mathematical, reading, and reasoning skills. The concern for group equivalence on this measure resulted from the potential for interaction between aptitude and training programs.

The study was designed in two parts: a pilot phase, using two classes, in which the training, control, and data collection methods were checked out; and a test phase, using seven FAOBC classes, during which the principal data reported here were collected. Test classes, excluding the pilot phase, were assigned to the experimental conditions as follows:

Class	(Subject N)	Experimental conditions 1	2	3	4	5	6	7	8
9-76	(107)	x					x	x	x
11-76	(84)	x					x	x	x
12-76	(59)					x			x
13-76	(100)		x	x	x				x
14-76	(86)			x					x
1-7T	(138)			x	x		x		x
2-7T	(138)	x	x		x				x

Data Collection. Three types of data were collected: performance data, questionnaire data, and situation descriptive data. USAFAS instructors collected all of the data. The performance data were collected on students as they performed their missions during the Daly and Arbuckle Hill training events and during each of the three criterion events. The performance data collected during the training events were used to assess learning behaviors which might explain performance differences in the criterion events. The performance data collected during the criterion events were used to assess the relative training effectiveness of each experimental training condition. The performance data collected were

1. Accuracy of initial target location.
2. Accuracy of final fire-for-effect rounds.
3. Time to locate target.
4. Total mission time.
5. Number of rounds fired.
6. Procedural errors cut score.
7. Total cuts score.

Data collected were separated into four subgroups, defined by mission type and location method: adjust fire mission-grid coordinates method; adjust fire mission-polar plot method; immediate suppression mission-grid coordinates method; and immediate suppression mission-polar plot method. This separation was necessary due to performance differences between these subgroups as a function of mission criteria and procedural differences.

The above performance measures 1 through 7 assess the performance of both the individual student and the system, and of both performance during a mission phase and in the overall mission. Items 1 and 3 above are the purest measures of student performance per se. They assess those individual skills applied during the first phase of the indirect fire control mission. Items 2, 4, and 5 are measures of the total mission performance effectiveness by the total indirect fire control system. These measures partially reflect the effectiveness of the FO. But, they also include the effects of variations among the FDC and firing battery components of the system, as well as other conditions--e.g., weather. Variation in these factors can be assumed to be random variations, not systematically affected by the training conditions. To the extent that this is true, these three items are the most important measures from an operational point of view. The major problem in using these measures is that the random variation of these factors may operate to conceal differences in FO effectiveness actually existing as an effect of the training conditions. This is a statistical and empirical question to be answered through analysis. Items 6 and 7 above are instructor judgments of procedural errors (primarily as observed in erroneous communications to the FDC) and of wasted time or rounds of ammunition. They are direct FO performance measures which assess procedural skills. Data on these two measures were expected to vary as a function of instructor differences as well as student skill differences. Multiple instructors were randomly assigned to each condition to minimize the effect of instructor differences.

Questionnaire data were collected from both students and instructors in FAOBC and FAOAC. Students were asked to judge the effectiveness of the BT33 in training different aspects of FO performance (e.g., communication procedures vs. range estimation), how well it was being utilized, and what might be done to improve its effectiveness. Instructors judged apparent device effectiveness, how well it facilitated the instructional process, and any problems and problem solutions. Opinions were also obtained from the device operators concerning operability, maintainability, operator training requirements, and design improvements. The questionnaires are presented in appendix A.

Situation descriptive data were collected to allow an assessment of whether or not bias was introduced from uncontrolled factors and to enable statistical control where necessary. The principal data collected were instructor names, event dates, event weather conditions, and instructor backgrounds and experience.

Analysis Procedures

The Questions. The purposes of the study can be translated into questions concerning training effectiveness, learning behaviors, device design, and device usage:

- What is the demonstrated relative training effectiveness of the BT33 in training for live-fire FO missions?

- What is the judged relative training effectiveness of the BT33 in training for live-fire FO missions?
- Are the training programs differentially effective for students of different aptitude levels?
- How well is the BT33 designed from a human factors standpoint?
- How well does the BT33 facilitate instruction as compared to training events consisting of live-fire?
- To what extent do students and instructors want to use the BT33 for training purposes?
- Can the BT33 be useful in student evaluation?

The Data Sources and Analyses. Each of the above questions will be discussed in the following paragraphs with regard to the analysis requirements and the data sources.

a. What is the demonstrated relative training effectiveness of the BT33 in training for live-fire FO missions?

The data sources for this question were the performance data from the three criterion events. The principal data subgroup was the adjust fire mission-grid coordinates method, as this is the most frequent mission and method combination employed. Answers to this question will consist of seven RE_k values, one for each of the seven experimental conditions. RE_k is a measure of the relative training effectiveness of the experimental condition as compared to the current training condition. A value of $RE_k = 1.0$ implies that the kth experimental condition trains as effectively, but no more so, as the current training program.

The RE_k values are an average of the elements RE_{ijk} where:

$$RE_{ijk} = \frac{C_{ij}}{E_{ijk}} \quad *$$

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*It should be noted that the relative effectiveness measure suggested by TRADOC (TRADOC Pam 71-8, Analyzing Training Effectiveness, Headquarters, U.S. Army Training and Doctrine Command, Fort Monroe, Va., 1975) is E divided by C, which is appropriate when the measures of E and C are such that a larger value means better performance. In this study, however, all seven of the performance measures are defined such that a smaller value is better. This being the case, C divided by E was selected as the relative effectiveness measure so that the effectiveness ratio would yield values consistent with usual expectations (less than 1.0 is a worse condition, greater than 1.0 is a better condition).

where: C = the mean criterion performance score resulting from the standard method of FO training, experimental condition no. 8;

E = the mean criterion performance score resulting from any one of the BT33 training conditions, experimental conditions no. 1-7;

and i = performance measure i of measure nos. 1-7;

j = criterion event j, with Mobile Shoot One = 1, Bunker Shoot = 2, and Mobile Shoot Two = 3; and

k = experimental condition no. k of conditions nos. 1-7.

The RE_{ijk} values combine across i and j to form the seven RE_k values as follows:

$$RE_k = \frac{\sum_{j=1}^{3} \sum_{i=1}^{7} RE_{ijk}}{21} .$$

b. What is the judged relative training effectiveness of the BT33 in training for live-fire FO missions?

The data were responses to Student Questionnaire items 1, 2a, 2b, 3, and 4; and Instructor Questionnaire items 1 and 4c-4f. The analysis principally consisted of an examination of the means and standard deviations of the rating responses and an evaluation of the written responses. Also two-way 4x7 least squares ANOVAs were run: the four aptitude levels by the seven experimental conditions wherein the students trained on the BT33. However, due to missing data, not all experimental conditions had samples from the four aptitude categories. The five or six missing cells appeared random in nature. The SPSS computer program option chosen for testing the main effects consisted of fitting the joint effects of both factors and then removing any effect which might be attributable to the other factor. The results of these analyses were used to address both this question and the following one.

c. Are the training programs differentially effective for students of different aptitude levels?

The data included all performance data on criterion events and questionnaire rating response data. The ANOVAs conducted on these data were described under the questions above.

d. How well is the BT33 designed from a human factors standpoint?

The data are responses to Instructor Questionnaire items 8 and 9; and Operator Questionnaire items 1-8. The means and standard deviations of the rating responses were examined.

e. How well does the BT33 facilitate instruction as compared to training events consisting of live fire?

The data are performance data on measure 4, Total Mission Time, and the Instructor Evaluation Questionnaire, items 6 and 7. The total mission times for training events taking place in the BT33 were compared to training event total mission times on the range to determine if a time difference existed. The means and standard deviations of the rating responses were examined.

f. To what extent do students and instructors want to use the BT33 for training purposes?

The data sources are the Instructor Evaluation Questionnaire, item 2, and the Student Evaluation Questionnaire, item 6. The means and standard deviations of the rating responses were examined.

g. Can the BT33 be useful in student evaluation?

The data sources are the Instructor Evaluation Questionnaire, item 5, and the Student Evaluation Questionnaire, item 4d. The written responses were tabulated and categorized.

Special Data Adjustments. It was noted in an earlier section that performance scores on the Mobile Shoots did differ as a function of range difficulty and that the difference between ranges would be controlled statistically. Data obtained for individuals performing either Mobile Shoot on the East range were adjusted to conform to that obtained for individuals actually performing the same Mobile Shoot on the West range. The adjustment was made separately for Adjust Fire Missions and for Immediate Suppression missions, and for each shoot. The adjustment process consisted of two steps: (1) identification of actual differences in performance through examination of means and standard deviations of scores (for all variables) obtained by students on each range for each shoot by mission type; and (2) transforming all East range scores (for all variables) to the equivalent of a West range score through a modified z-score transformation process. The formula is:

$$x_{WE_{ijk}} = (x_{E_{ijk}} - \bar{x}_{E_{jk}}) \left[\frac{s_{W_{jk}}}{s_{E_{jk}}}\right] + \bar{x}_{W_{jk}}$$

Where: $x_{E_{ijk}}$ = individual score on East range

$x_{WE_{ijk}}$ = translated (West) equivalent score

$\bar{x}$ = mean

s = standard deviation

and i = individual score

j = performance measure

k = mission type.

RESULTS

Performance Data

Data availability was analyzed for the four procedural conditions, based on mission type and location method, identified in the Design section. It was found that only two combinations were used consistently enough to provide N's sufficiently large for analysis. Approximately 60 percent of the data was obtained for the Adjust Fire mission using Grid Coordinates for location. This data set was fully usable for analysis among experimental conditions and only these data are reported here. Data obtained for the Immediate Suppression mission using the Grid Coordinates for location provided a somewhat less adequate sample. Several experimental conditions had no data obtained under this combination. Summary results of this data subgroup are presented in appendix B to this report. The other two procedural combinations occurred so rarely in the test situation that data for these conditions could not be analyzed.

The computer raw data printouts on all of the measures were examined and found to be reasonable except for the Accuracy of Final Fire for Effect Rounds measure. The data on this measure had been reduced improperly. Hence this measure was dropped from the analyses.

ANOVA and ANCOVA Results. The results of the ANOVAs are listed in Table 1. Seeing that aptitude was a significant factor in seven of the analyses and the interaction between aptitude and experimental condition was significant in six, ANCOVAs, using the actual STEP score as the covariate, were performed. The results of these analyses appear in Table 2.

In reviewing Table 2, it can be seen that aptitude is significantly related to the performance measures as follows:

Table 1

A Summary of Significant Findings Resulting from ANOVAs on the Adjust Fire-Grid Coordinates Data

	Training events				Criterion events					
	Daly Hill		Arbuckle Hill		Mobile Shoot One		Bunker Shoot		Mobile Shoot Two	
Time to Locate Target (Seconds)	A*	----****	A	---	A	---	A	---	A	---
	EC**	---	EC	---	EC	---	EC	---	EC	---
	AxEC***	---	AxEC	---	AxEC	---	AxEC	---	AxEC	---
Total Mission Time (Seconds)	A	p=.001	A	---	A	---	A	---	A	---
	EC	p=.001	EC	p=.001	EC	---	EC	p=.012	EC	---
	AxEC	---	AxEC	p=.001	AxEC	---	AxEC	---	AxEC	p=.037
Accuracy of Initial Target Location (Radial error, Meters)	A	---	A	p=.001	A	---	A	---	A	---
	EC	---	EC	p=.002	EC	---	EC	p=.050	EC	---
	AxEC	---	AxEC	---	AxEC	---	AxEC	---	AxEC	p=.020
Number of Rounds Fired	A	---	A	---	A	---	A	---	A	p=.013
	EC	p=.001	EC	p=.001	EC	---	EC	---	EC	---
	AxEC	---	AxEC	---	AxEC	---	AxEC	---	AxEC	---
Procedural Errors Cut Score	A	---	A	p=.001	A	p=.011	A	---	A	---
	EC	---	EC	p=.001	EC	---	EC	---	EC	---
	AxEC	---	AxEC	---	AxEC	---	AxEC	---	AxEC	---
Total Cuts Score	A	---	A	p=.001	A	p=.032	A	---	A	---
	EC	---	EC	p=.001	EC	---	EC	---	EC	---
	AxEC	---	AxEC	p=.002	AxEC	---	AxEC	p=.031	AxEC	p=.002

*A = Aptitude factor.
**EC = Experimental Condition factor.
***AxEC = Aptitude and Experimental Condition interaction.
****A blank means that p > .050.

Table 2

A Summary of Significant Findings Resulting from ANCOVAs on the Adjust Fire-Grid Coordinates Data

	Training events		Criterion events		
	Daly Hill	Arbuckle Hill	Mobile Shoot One	Bunker Shoot	Mobile Shoot Two
Time to Locate Target (Seconds)	CovA* p=.043 EC** ---***	CovA --- EC ---	CovA --- EC ---	CovA p=.028 EC ---	CovA --- EC ---
Total Mission Time (Seconds)	CovA p=.006 EC p=.001	CovA p=.053 EC p=.001	CovA --- EC p=.025	CovA p=.008 EC p=.008	CovA p=.094 EC ---
Accuracy of Initial Target Location (Radial error, Meters)	CovA --- EC ---	CovA --- EC ---	CovA p=.037 EC ---	CovA --- EC ---	CovA --- EC ---
Number of Rounds Fired	CovA --- EC p=.001	CovA --- EC p=.001	CovA --- EC ---	CovA --- EC ---	CovA --- EC ---
Procedural Errors Cut Score	CovA --- EC ---	CovA p=.001 EC p=.001	CovA p=.029 EC ---	CovA --- EC ---	CovA --- EC ---
Total Cuts Score	CovA --- EC ---	CovA --- EC ---	CovA --- EC ---	CovA --- EC p=.033	CovA p=.028 EC ---

*Covariate Aptitude.
**Experimental Condition factor.
***A blank means that p for CovA > .100 or p for EC > .050, as appropriate.

Covaries on four events: Total Mission Time.

Covaries on two events: Time to Locate Target and Procedural Errors Cut Score.

Covaries on one event: Accuracy of Initial Target Location and Total Cuts Score.

Covaries on no events: Number of Rounds Fired.

This means that for these events the individual performance measure scores were partially dependent upon the aptitude level (the STEP score) of the student. On further examination of the relationship, however, no linear trends were observed. On some events and for some measures students with high STEP scores did better than those with low scores. On other events and other measures the reverse was true. Also, in some cases, the performance of students scoring in the mid ranges was better than that of either high- or low-scoring students. In short, there were no definitive trends in the data. There is no indication of consistent differential effectiveness of these training programs as a function of student aptitude.

The most important occasions where experimental condition was a significant factor are the criterion events. This is for two reasons. One, because differences between conditions in training events were sometimes primarily a function of field vs. simulator situational differences (as in total mission time). And, two, because the principal matter of concern here is whether the differences between the experimental groups, and hence the RE_k value differences, are significant. Looking, therefore, at only the criterion event results in Table 2, we see that performances varied significantly as a function of experimental condition in only 3 cases out of 18: twice on the Total Mission Time measure and once on the Total Cuts Score.

Mean Scores and RE Values. There are two possible sets of mean performance scores per measure: (1) means based on the raw data and (2) means that have been adjusted for the effect of the covariate, aptitude. Tables 3 through 8 present the subject Ns and mean scores based on the raw data for the Adjust Fire Mission-Grid Coordinates method data subgroup. Tables 9 through 13 present the covariate adjusted means for those measures and event combinations where the covariate was significant at the .10 level or better.

So as to provide the reader with at least one graphic view of the results, Figure 1 was developed for the Time to Locate Target measure. The raw data means or the adjusted means were used as appropriate, using Tables 3 and 9. In viewing this graph, the overall learning trend is apparent between Mobile Shoot One and Two, as is the comparative ease of the Bunker Shoot. One thing that can be observed in this graph, and also occurred on some other measures, is change in relative position of the students who had experimental condition 7 (all BT33 substitution)

Table 3

Time to Locate Target (Seconds) Raw Data Means by Event and Condition
(Adjust Fire-Grid Coordinates Data Subgroup)

	Training events		Criterion events		
Experimental conditions	Daly Hill	Arbuckle Hill	Mobile Shoot One	Bunker Shoot	Mobile Shoot Two
#1 (SXX)	22* 48**	29 40	35 32	7 25	39 30
#2 (XSX)	4 42	19 41	16 37	3 32	9 27
#3 (XXS)	17 38	43 32	25 30	14 21	22 32
#4 (SSX)	8 38	20 45	25 34	9 33	13 32
#5 (SXS)	10 52	8 36	9 21	4 25	9 26
#6 (XSS)	12 50	25 45	34 34	9 25	37 29
#7 (SSS)	9 33	23 43	25 38	17 27	33 25
#8 (XXX)	72 49	74 38	83 35	37 27	60 30

*Subject N (N variations primarily due to mission-target location method choices).
**Mean performance score.

Table 4

Total Mission Time (Seconds) Raw Data Means by Event and Condition
(Adjust Fire-Grid Coordinates Data Subgroup)

	Training events		Criterion events		
Experimental conditions	Daly Hill	Arbuckle Hill	Mobile Shoot One	Bunker Shoot	Mobile Shoot Two
#1 (SXX)	22* 1068**	29 715	35 566	7 679	39 762
#2 (XSX)	4 466	1 1260	16 521	5 1024	8 671
#3 (XXS)	16 984	36 201	25 401	10 241	24 904
#4 (SSX)	8 465	17 807	25 537	9 442	13 671
#5 (SXS)	10 933	6 1360	9 337	5 505	6 612
#6 (XSS)	12 572	25 387	34 640	9 655	37 653
#7 (SSS)	9 357	23 285	22 585	13 436	33 578
#8 (XXX)	72 792	68 680	82 532	32 441	64 741

*Subject N.
**Mean performance score.

Table 5

Accuracy of Initial Target Location (Radial Error, Meters) Raw Data Means by Event and Condition (Adjust Fire-Grid Coordinates Data Subgroup)

	Training events		Criterion events		
Experimental conditions	Daly Hill	Arbuckle Hill	Mobile Shoot One	Bunker Shoot	Mobile Shoot Two
#1 (SXX)	22* 372**	28 370	34 424	7 218	38 271
#2 (XSX)	4 185	19 635	14 431	3 577	9 339
#3 (XXS)	17 322	49 398	22 336	14 151	22 327
#4 (SSX)	9 282	20 400	26 317	9 178	13 209
#5 (SXS)	10 562	9 425	8 637	3 114	9 213
#6 (XSS)	12 434	25 391	28 456	6 376	35 283
#7 (SSS)	9 394	23 328	25 287	17 235	28 283
#8 (XXX)	72 572	78 376	82 373	38 203	59 343

*Subject N.
**Mean performance score.

Table 6

Number of Rounds Fired Raw Data Means by Event and Condition (Adjust Fire-Grid Coordinates Data Subgroup)

	Training events		Criterion events		
Experimental conditions	Daly Hill	Arbuckle Hill	Mobile Shoot One	Bunker Shoot	Mobile Shoot Two
#1 (SXX)	22* 5.3**	29 5.1	36 4.6	7 3.9	39 5.4
#2 (XSX)	4 3.8	19 4.9	16 5.2	5 6.2	9 4.2
#3 (XXS)	17 6.6	51 4.1	25 4.9	14 3.7	24 5.5
#4 (SSX)	9 4.1	19 5.2	27 4.7	10 4.4	13 5.2
#5 (SXS)	12 5.1	9 6.4	9 5.6	5 5.8	10 5.4
#6 (XSS)	12 8.9	26 8.0	34 5.6	41 4.8	37 5.0
#7 (SSS)	9 8.0	24 13.0	25 4.5	21 4.0	33 5.8
#8 (XXX)	71 5.4	78 5.2	84 4.7	43 4.7	63 5.7

*Subject N.
**Mean performance score.

Table 7

Procedural Errors Cut Score Raw Data Means by Event and Condition
(Adjust Fire-Grid Coordinates Data Subgroup)

	Training events		Criterion events		
Experimental conditions	Daly Hill	Arbuckle Hill	Mobile Shoot One	Bunker Shoot	Mobile Shoot Two
#1 (SXX)	22* 10.0**	29 14.3	36 9.0	7 3.4	39 11.4
#2 (XSX)	4 7.5	19 10.0	16 10.6	5 12.6	9 9.9
#3 (XXS)	17 9.5	51 7.0	25 6.3	14 10.8	24 9.8
#4 (SSX)	9 5.7	20 8.0	37 7.1	10 3.9	13 10.3
#5 (SXS)	12 18.5	9 12.8	9 11.4	5 8.6	10 6.0
#6 (XSS)	12 14.6	26 16.5	34 7.5	9 2.0	37 9.0
#7 (SSS)	9 13.1	23 10.9	25 9.0	21 7.2	33 5.7
#8 (XXX)	72 13.3	78 8.9	84 7.3	43 7.2	63 8.5

*Subject N.
**Mean performance score.

Table 8

Total Cuts Score Raw Data Means by Event and Condition (Adjust Fire-Grid Coordinates Data Subgroup)

Experimental conditions	Training events		Criterion events		
	Daly Hill	Arbuckle Hill	Mobile Shoot One	Bunker Shoot	Mobile Shoot Two
#1 (SXX)	22* 26.8**	29 24.9	34 16.6	7 4.9	39 21.4
#2 (XSX)	4 13.5	19 31.3	16 23.8	5 16.6	9 16.9
#3 (XXS)	17 30.1	51 26.7	21 19.9	14 9.4	24 18.5
#4 (SSX)	9 24.4	20 29.9	27 17.1	10 5.9	13 22.2
#5 (SXS)	12 34.3	9 29.8	9 23.5	5 17.2	9 10.9
#6 (XSS)	12 34.5	26 28.0	34 20.0	9 20.1	37 16.3
#7 (SSS)	9 19.3	23 22.8	24 17.1	21 16.0	33 13.7
#8 (XXX)	72 29.1	78 23.1	79 16.8	43 13.2	63 21.7

*Subject N.
**Mean performance score.

Table 9

Time to Locate Target (Seconds) Aptitude Covariate Adjusted Data Means by Event and Condition (Adjust Fire-Grid Coordinates Data Subgroup)

	Training events			Criterion events	
Experimental conditions	Daly Hill	---	---	Bunker Shoot	---
#1 (SXX)	22* 50**			7 26	
#2 (XSX)	4 41			3 27	
#3 (XXS)	16 38			10 22	
#4 (SSX)	8 41			9 34	
#5 (SXS)	8 53			3 17	
#6 (XSS)	12 50			9 26	
#7 (SSS)	9 31			13 24	
#8 (XXX)	70 47			32 26	

*Subject N.
**Mean performance score.

Table 10

Accuracy of Initial Target Location (Radial Error, Meters) Aptitude Covariate Adjusted Data Means by Event and Condition (Adjust Fire-Grid Coordinates Data Subgroup)

	Training events		Criterion events		
Experimental conditions	---	---	Mobile Shoot One	---	---
#1 (SXX)			32* 416**		
#2 (XSX)			13 463		
#3 (XXS)			18 380		
#4 (SSX)			26 317		
#5 (SXS)			6 732		
#6 (XSS)			28 442		
#7 (SSS)			24 289		
#8 (XXX)			76 383		

*Subject N.
**Mean performance score.

Table 11

Total Mission Time (Seconds) Aptitude Covariate Adjusted Data Means by Event and Condition (Adjust Fire-Grid Coordinates Data Subgroup)

	Training events		Criterion events		
Experimental conditions	Daly Hill	Arbuckle Hill	---	Bunker Shoot	Mobile Shoot Two
#1 (SXX)	22* 1141**	29 708		7 717	39 767
#2 (XSX)	4 449	19 1249		3 200	8 655
#3 (XXS)	16 943	36 205		10 298	22 923
#4 (SSX)	8 537	17 798		9 474	13 662
#5 (SXS)	8 1010	4 1322		3 291	5 657
#6 (XSS)	12 565	24 374		9 664	37 638
#7 (SSS)	9 313	23 289		13 416	33 573
#8 (XXX)	70 756	67 688		32 439	57 738

*Subject N.
**Mean performance score.

Table 12

Procedural Errors Cut Score Aptitude Covariate Adjusted Data Means by Event and Condition (Adjust Fire-Grid Coordinates Data Subgroup)

	Training events		Criterion events		
Experimental conditions	---	Arbuckle Hill	Mobile Shoot One	---	---
#1 (SXX)		23* 12.8**	32 8.8		
#2 (XSX)		11 11.0	13 10.8		
#3 (XXS)		17 6.8	18 8.0		
#4 (SSX)		14 6.8	26 7.1		
#5 (SXS)		7 10.7	6 14.0		
#6 (XSS)		18 20.3	28 6.7		
#7 (SSS)		8 15.6	24 9.2		
#8 (XXX)		54 7.9	76 8.0		

*Subject N.
**Mean performance score.

Table 13

Total Cuts Score Aptitude Covariate Adjusted Data Means by Event and Condition
(Adjust Fire-Grid Coordinates Data Subgroup)

	Training events		Criterion events		
Experimental conditions	---	---	---	---	Mobile Shoot Two
#1 (SXX)					38* 21.1**
#2 (XSX)					- - - - -
#3 (XXS)					8 20.9
#4 (SSX)					7 13.9
#5 (SXS)					- - - - -
#6 (XSS)					35 15.6
#7 (SSS)					28 14.6
#8 (XXX)					34 23.8

*Subject N.
**Mean performance score.

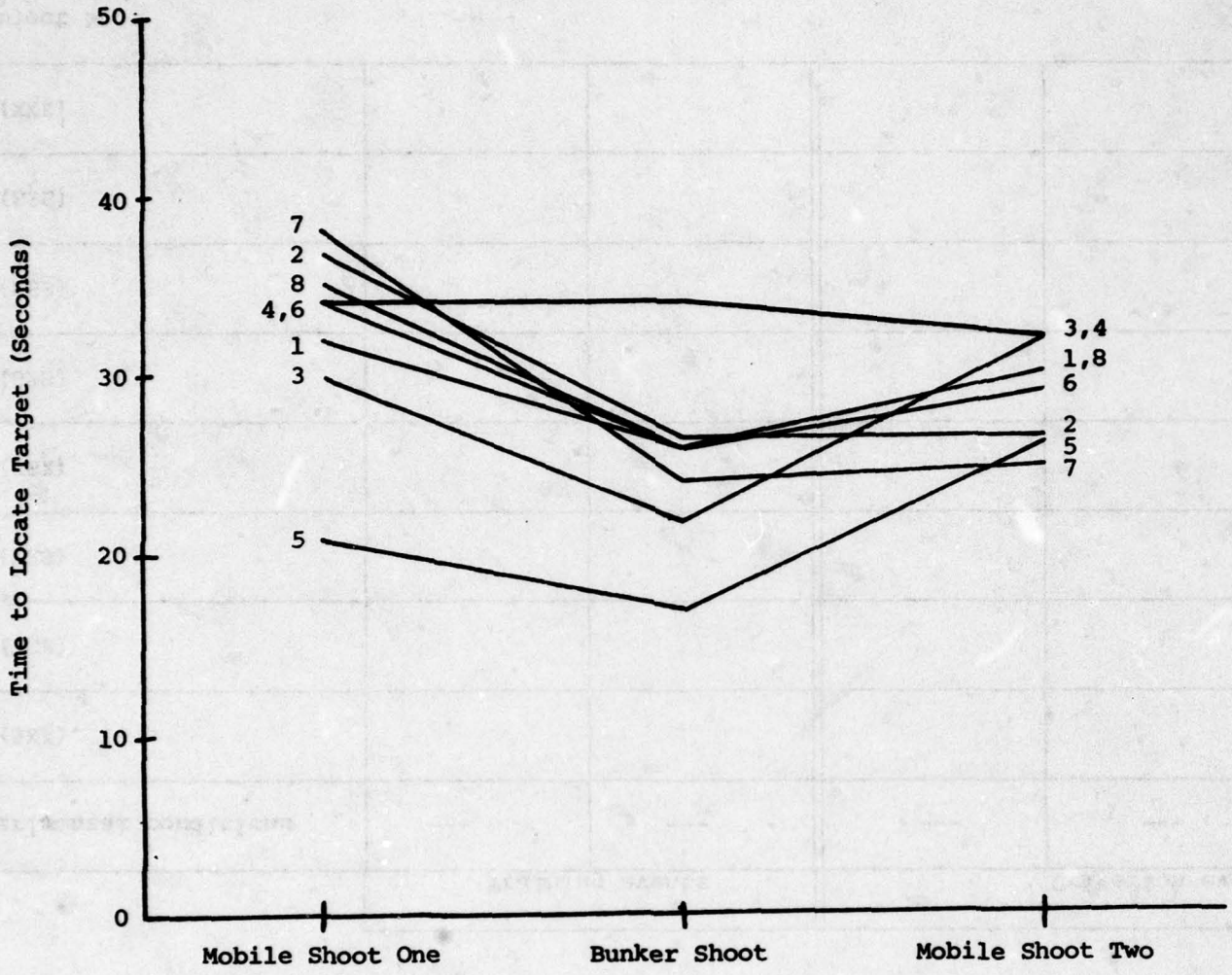

Figure 1. Mean scores obtained on the eight experimental conditions across the three criterion events for the Time to Locate Target (Seconds) performance measure (Adjust Fire-Grid Coordinates data subgroup).

across criterion events. On Mobile Shoot One they were the poorest performing group, on the Bunker Shoot they were intermediate, and on the final Mobile Shoot Two they were the best performing group. This same trend did not occur for all measures or for all experimental conditions. Examination of Tables 3 through 13 shows that Time to Locate Target and Accuracy of Initial Target Location did decrease from Mobile Shoot One to Mobile Shoot Two. However, Total Mission Time (Table 4) showed an increase over these same shoots; while the Number of Rounds Fired (Table 6), Procedural Errors (Table 7), and Total Cuts Scores (Table 8) showed mixed changes by condition with the scores being closely similar overall from the first to the second Mobile Shoot.

It was hypothesized that one advantage of the BT33 over the live-fire situation may be a reduction in time needed per mission. The live-fire shoot was thought to take longer due to the delayed response from the FDC. If this is true then either more students could shoot more missions per training period in the BT33, and thus receive more practice, or the training time could be reduced, resulting in a savings. The mean total mission times per BT33 versus live-fire sessions were computed for the training events and it was found that the anticipated time saving for the BT33 missions was indeed realized: 8.5 minutes versus 15.2 minutes, a difference of 6.7 minutes or 44%.

RE_{ijk} values were calculated using either raw data means or covariate adjusted means according to the rule: If the covariate was significant at the .100 level or better then the adjusted means were used; otherwise the raw data means were used. These RE_{ijk} values are presented in appendix C. The overall RE_{jk}, RE_j, and RE_k values are summarized in Table 14. Given that experimental condition generally did not account for a significant amount of the performance variance, small differences between these values are not important.

Review of Table 14 brings out some overall trends of interest with respect to each of the RE indices. A close examination of the RE_{jk} values discloses that the relative position of conditions changes in many cases across events. For example, experimental conditions 3 and 4 (XXS and SSX) have the highest ratings on Mobile Shoot One and lower relative positions on Mobile Shoot Two. Conditions 5 and 6 (SXS and XSS), on the other hand, occupy lower relative positions on Mobile Shoot One and higher relative positions on Mobile Shoot Two. Which simply says that the condition which results in the best initial live-fire graded event performance is not necessarily the one which results in the best ultimate performance. In looking at the RE_j values, it can be noted that, overall, experimental conditions incorporating the BT33 result in performance equivalent to the current program in Mobile Shoot One (RE_j = .98) and better than the current program in the Bunker Shoot and Mobile Shoot Two (RE_j = 1.20, 1.18). With regard to RE_k values, the overall order of the experimental conditions with respect to training effectiveness is:

Experimental conditions	RE_k
#4 (SSX)	1.20
#5 (SXS)	1.19
#7 (SSS)	1.12
#1 (SXX)	1.11
#6 (XSS)	1.10
#3 (XXS)	1.08
#8 (XXX)	1.00
#2 (XSX)	.98

It can be seen that the RE_k values fall into three groups, with conditions 4 and 5 being the best, and conditions 2 and 8 being the poorest.

Table 14

RE_{jk}, RE_j, and RE_k Values

Experimental condition	Events: Mobile Shoot One	Bunker Shoot	Mobile Shoot Two	RE_k values
#1 (SXX)	.98	1.43	1.03	1.11
#2 (XSX)	.86	.94	1.13	.98
#3 (XXS)	1.05	1.22	.97	1.08
#4 (SSX)	1.06	1.33	1.22	1.20
#5 (SXS)	.98	1.21	1.39	1.19
#6 (XSS)	.93	1.21	1.17	1.10
#7 (SSS)	1.01	1.04	1.32	1.12
#8 (XXX)	1.00	1.00	1.00	1.00
RE_j values	.98	1.20	1.18	

It is again pointed out that the ANCOVAs determined that the differences between performance as a function of experimental condition were significant in only 3 cases out of 18. Hence, although the above RE_j and RE_k values are of interest, the differences between them are of negligible importance. Given the lack of statistical significance in the performance differences, the cost savings to be realized from use of FO training devices is of greater importance.

Questionnaire Data

FAOBC Student Evaluation. This questionnaire is contained in appendix A. Student responses are discussed in the following paragraphs. Mean responses to rating questions are listed in Table 15. The data on each questionnaire item were analyzed (ANOVA) to determine if either experimental condition or aptitude determined the responses. Where either a main effect or interaction influence was significant, this will be discussed.

a. FAOBC Questionnaire items 1 and 2.

The first four rating questions, contained in questionnaire items 1 and 2, asked the student to evaluate the effectiveness of the BT33--both overall and for specific clusters of skills. It is clear from the mean ratings that while the device is rated overall as moderately effective ($\bar{x}$ = 3.2), it is seen to be most effective as a procedures and communications skills trainer ($\bar{x}$ = 3.9, 3.7) and somewhat less effective as a visual/perceptual skills trainer ($\bar{x}$ = 2.4).

The basis for these ratings is spelled out in the responses to item 2b concerning differences between performance in the BT33 vs. on the range. Nineteen percent indicated procedural differences exist and 13% indicated communications differences; but 71% felt that visual/perceptual differences exist.

If the FAOBC students indicated that a difference did exist, they were to describe the difference, the duration of its impact on range performance, and suggestions for improvement. The differences noted primarily revolved around visual/perceptual problems with the BT33. The problems included difficulty in range estimation, lateral shift estimation, height of burst (HOB) estimation, and rounds spotting in the BT33 with a short term impact on range performance. The suggestions included improvement of the film quality, the inclusion of pictures of Fort Sill terrain (as opposed to the shots of European terrain supplied by SAAB-Scania), and the possibility of 3-D projection.

Although few students noted any differences with respect to communications skills, some who did felt that the instructors were not being sufficiently strict in the BT33 and were allowing incomplete transmissions in the BT33 classroom environment. Others suggested the addition of radios or phones to the BT33 simulation.

ANOVAs on the four rating questions in items 1 and 2 determined that experimental condition was a significant response determining factor on three of these. The individual means per condition for these three questions are presented in Table 16.

Table 15

FAOBC Student Evaluation Questionnaire
Grand Means (N's = 138-278)

Questionnaire item	Mean rating
1. Overall BT33 training effectiveness	3.2*
2. BT33 effectiveness: Procedural skills training	3.9
BT33 effectiveness: Communication skills training	3.7
BT33 effectiveness: Visual/perceptual skills training	2.4
3. Puffboard vs. live-fire effectiveness: Overall	2.0
BT33 vs. live-fire effectiveness: Overall	2.5
4. BT33 vs. live-fire effectiveness: Puffboard	3.0
BT33 vs. live-fire effectiveness: Daly Hill	2.5
BT33 vs. live-fire effectiveness: Arbuckle Hill	2.3
BT33 vs. live-fire effectiveness: Bunker Shoot	2.2
BT33 vs. live-fire effectiveness: Mobile Shoot One	2.0
BT33 vs. live-fire effectiveness: Mobile Shoot Two	2.0
6. BT33 availability for practice desirability	3.5

*Items rated on a 5-point scale with 1.0 = very low and 5.0 = very high.

Table 16

Mean FAOBC Question Responses as a Function of Experimental Condition (N's = 19-72)

FAOBC questions (items 1 and 2)	Experimental conditions 1 SXX	2 XSX	3 XXS	4 SSX	5 SXS	6 XSS	7 SSS
Overall effectiveness*	3.0	3.2	3.5	3.1	3.1	3.0	3.4
Procedural skills effective**	3.7	4.2	4.3	3.8	3.7	3.9	4.3
Communication skills effectiveness***	3.6	4.0	3.8	3.5	3.7	3.5	4.2

*Experimental condition p = .046, Aptitude Interaction p = .027.
**Experimental condition p = .019.
***Experimental condition p = .042.

In examining the above, certain overall trends can be noted. The students exposed to the BT33 only once (experimental condition No. 1) tended to give low ratings to all three questions. Students exposed to the BT33 the maximum amount (condition No. 7) tended to give the highest ratings on BT33 effectiveness. Students exposed to a mix of Puffboard, BT33, and live-fire training exercises (conditions 2 and 3) tended to give moderately higher ratings. Finally, students exposed to the BT33 twice, with either the Puffboard or live fire on the other training event, tended to give moderately lower ratings.

The interaction effect was uninterpretable due to empty cells. It can only be noted that on the first question, concerning overall BT33 effectiveness, the responses across the four aptitude categories did interact with the experimental conditions.

b. FAOBC Questionnaire item 3.

The two rating questions contained in this item compared the training effectiveness of the Puffboard and the BT33 to that of a live-fire exercise. Although both were judged to be somewhat less effective than a live-fire exercise, the BT33 received a higher rating than did the Puffboard ($\bar{x}$ = 2.5 vs. 2.0).

c. FAOBC Questionnaire item 4.

Item 4 contained six rating questions, one yes/no question, and a verbal response question. The rating questions (see Table 15) were more specific versions of item 3, where the student was asked to judge the comparative effectiveness of the BT33 in place of each of the current training and criterion events. The responses were as might be expected--highest for the first training event ($\bar{x}$ = 3.0) and gradually declining to smaller values on the final criterion events ($\bar{x}$ = 2.2, 2.0). Data on three of the six rating questions (item 4b) were influenced significantly (p = .040, .038, and .002) by an interaction between the aptitude factor levels and the experimental conditions. Due, however, to empty cells the impact is uninterpretable.

The yes/no question under item 4d concerned the possible use of the BT33 for student evaluation purposes: "Do you think a realistic evaluation of your skills could be made in the BT33 rather than at Bunker Hill?" Seventy-seven percent of the students responded "no" to this question.

The verbal response question asked: "Are there any other FAOBC field exercises where the BT33 might be an effective substitute?" Responses pointed to the following:

- The terrain association class, a dry-fire shack shoot, held at Apache Ridge;
- Whenever an event is weathered out;
- Could be used in conjunction with the FDC (FAOAC) exercise;
- Could be a means of later technique polishing and to maintain proficiency; and
- Should not be used as a substitute, but could be a valuable addition, especially for procedural and communications skills development.

d. FAOBC Questionnaire item 5.

Item 5 asked for student recommendations for improvement of the BT33. The first area covered (item 5a) was terrain, target, and burst presentations. Here the students made the following recommendations, with the first two appearing most frequently:

- Make the burst presentations longer, clearer, and with greater realism. When burst is in woods, display a puff of smoke.
- Use displays of different types of terrain, including shots of difficult Fort Sill terrain, and change them more frequently during training.

- Improve the sharpness of the terrain display, but provide fewer terrain features.

- Simulate a mobile shoot by using different shots of the same target area.

- Close targets need to be clearer and continuously displayed. Target size and clarity change would aid depth perception.

The second area covered (item 5b) was the manner in which the BT33 was used by instructors. The most frequent responses here were: (a) the instructors did a good job, (b) smaller classes would be very desirable so that more missions could be run for students, and (c) which students had performed a mission needed to be monitored more carefully in that not all students received an opportunity to perform during each event. Some students also urged that greater emphasis be placed on developing specific procedures, communications, and map reading skills.

The final question under this item (5c) was an open-ended one, asking, "Anything else?" The majority of the comments made here have already been presented under the above items 1 through 4. The only additional ideas were: (a) the BT33 should be made available for student use during evening hours and weekends and (b) the BT33 was useful in that it allowed the instructor to train students how to handle contingency situations like lost rounds and FDC errors.

e. FAOBC Questionnaire item 6.

Item 6 asked the student to indicate the extent to which he would like to have the BT33 available for additional practice outside the presently scheduled classes. The responses were generally moderately favorable, with a mean response of 3.5.

These data were influenced significantly by an aptitude X experimental condition interaction ($p = .026$). Due, however, to empty cells the results are uninterpretable.

FAOAC Student Evaluation. The FAOAC, MASOC, AIT, and III Corps Artillery questionnaire is presented in appendix A. It was responded to only by FAOAC students. The mean FAOAC student responses to rating questions are summarized in Table 17 and discussed in the following paragraph.

a. FAOAC Questionnaire items 1 and 2.

The FAOAC students gave the BT33 fairly high ratings on training effectiveness both overall ($\bar{x} = 3.5$) and for each of the three sets of skills ($\bar{x} = 3.1$ to 4.0). The ratings given by the FAOAC students were higher across the board than those given by the FAOBC students (compare Tables 15 and 17), but in agreement that the BT33 is most effective as a procedural and communications skills trainer and least

effective as a visual skills trainer. These judgments of differential effectiveness per skill type can again be explained by perceived differences between visual performance in the BT33 versus on the range. Only 12% perceived procedural differences to exist and only 16% perceived communications differences to exist; whereas 61% perceived visual/perceptual differences.

Table 17

FAOAC Student Evaluation Questionnaire Mean Responses

Questionnaire item	Mean rating
1. Overall BT33 training effectiveness (N = 142)	3.5
2. BT33 effectiveness: Procedural skills training (N = 142)	4.0
BT33 effectiveness: Communications skills training (N = 142)	3.5
BT33 effectiveness: Visual/Perceptual skills training (N = 142)	3.1
3. Puffboard vs. live-fire effectiveness: Overall (N = 48)	2.4
BT33 vs. live-fire effectiveness: Overall (N = 98)	3.1
4. BT33 vs. live-fire effectiveness: FAOAC program (N = 127)	2.9
6. BT33 availability for practice: Desirability (N = 111)	2.8

*Items rated on a 5-point scale with 1.0 = very low and 5.0 = very high.

If the FAOAC students indicated that a difference did exist, they were to describe the difference, the duration of its impact on range performance, and suggestions for improvement. The main differences noted were the lack of radios and 3-D displays. The principal problems noted revolved around the difficulty in visually estimating ranges and HOBs on a 2-D display where neither burst nor target sizes changed as a function of distance. The problem was apparently most acute for students seated close to the screen. The students generally felt the impact of this perceptual problem on range performance was short-lived. They recommended improved film quality, a greater variety of pictures, and 3-D projection.

b. FAOAC questionnaire items 3 and 4.

The FAOAC students also gave higher ratings to the two questions contained in item 3 than did the FAOBC students (compare Tables 15 and 17). They judged the Puffboard to be somewhat less effective than live fire ($\bar{x}$ = 2.4), while the BT33 was judged to be as effective overall as live fire ($\bar{x}$ = 3.1).

In judging the effectiveness of the BT33 in contrast with live fire for their specific FAOAC training program (question 4a), the students again judged the BT33 to be just about as training effective as live fire ($\bar{x}$ = 2.9). The responses to question 4b, "How often and in what manner do you think the BT33 might be best used in the FAOAC?," were grouped into the following categories:

Response category	% of total response (N = 145)
• The BT33 could be used entirely, eliminating live fire	4%
• The BT33 could be used "extensively," "frequently," or "equally"	9%
• The BT33 could be used once or twice for refresher training	78%
• The BT33 should not be used at all	9%

c. The FAOAC questionnaire item 5.

Questionnaire item 5 asked for recommendations for improvement of the BT33. The first question in this item concerned terrain, target, and burst presentations. The recommendations were

Terrain: provide more scenes

Targets: make more realistic

Bursts: color them; scale them, making the close in ones larger than the current ones; and display for a longer time.

The second question concerned the manner in which the BT33 is used by the instructors. The comments made here and elsewhere can best be represented by one of the responses: "Instructors must be sure that target location and orientation on the BT33 are accurately set up. Poor data inputs defeat the purpose with respect to student attitude." Granted, the BT33 can be used to introduce the students to the fallibilities of the FDC and gunnery. But the matter of how and when to do this apparently needs to be reconsidered.

The third question was a catchall, "Anything else?" All the ideas presented here have already been discussed elsewhere.

d. FAOAC questionnaire item 6.

Whereas the FAOAC students gave higher ratings than did the FAOBC students on all the preceding questions, they reversed the trend on this item. While the FAOBC students had indicated a definite desire to have the BT33 available for practice ($\bar{x}$ = 3.5), the more experienced FAOAC students did not feel a need to quite the same extent ($\bar{x}$ = 2.8).

Instructor Evaluation. The Instructor Evaluation Questionnaire is presented in appendix A. The mean instructor responses are summarized in Table 18 and discussed below.

Table 18

Instructor Evaluation Questionnaire Mean Responses

Questionnaire item	Mean rating
1. Overall BT33 training effectiveness (N = 19)	3.4
4. BT33 vs. range training environments:	
How well the student learns (N = 19)	2.5
How quickly the student learns (N = 19)	3.1
For FAOBC training (N = 9)	2.8
For FAOAC training (N = 5)	1.6
For AIT training (N = 4)	3.1
For MASOC training (N = 3)	3.3
For field FO training (N = 19)	2.2
6. BT33 facilitation of instructor-student interaction (N = 19)	3.0
7. BT33 facilitation of student learning problems diagnosis (N = 19)	2.9
8. Adequacy of BT33 presentation management (N = 19)	3.4

*Items rated on a 5-point scale with 1.0 = very low and 5.0 = very high.

a. Instructor Questionnaire items 1, 2, and 4.

The instructors rated the BT33 as fairly effective overall (item 1, $\bar{x}$ = 3.4). The FAOBC instructors (N = 9) indicated that 22% of FAOBC training could take place in the BT33 while the FAOAC instructors (N = 5) indicated 20% for FAOAC training (item 2).

Item 4 asked the instructors to make judgments regarding student learning behavior and the effectiveness of the BT33, as opposed to live fire, for specific training programs. Two of the items in Table 18, BT33 effectiveness for FAOAC training and for field FO training, were given rather low ratings and hence warrant comment. The low rating given by five instructors of BT33 effectiveness for FAOAC students ($\bar{x}$ = 1.6) seems to be in conflict with the moderately high rating given by the FAOAC students themselves (Table 17, $\bar{x}$ = 2.9)--but it may not be. The majority of the FAOAC students also indicated that the BT33 would be most useful for one or two FAOAC sessions but not much beyond that. This may be just what the instructors were saying as well.

The rating given with regard to field FO training, $\bar{x}$ = 2.2, is a more real rating in that it is based on a larger N of 19. It is also more of a problem in that the major objective of the OFT now under development is to provide this unit, or field, FO training. It may be that the instructors were actually rating the BT33 with respect to its lack of suitability for the more rugged unit environment rather than with respect to its training value. On the other hand, the ratings may indicate a real doubt regarding the value of a FO unit training device. If so, then the OFT CTEA may need to be extended to the unit environment with the LRIP models prior to initiating full rate production of the OFT. Certainly the opinions of the instructors regarding the value of a FO trainer in the unit environment need to be reexamined.

b. Instructor Questionnaire items 5 through 8.

Items 5 through 8 dealt with questions related to student management in the BT33 environment. The first of these, item 5, concerned the issue of whether student performance could be evaluated in the BT33. Forty-seven percent of the instructors felt that the answer was yes. These instructors generally felt that this evaluation should take place early in training to evaluate procedural learning and progress.

With regard to instructor capabilities to interact with students and diagnose their learning problems, the instructors seemed to feel that the BT33 and range environments were about the same ($\bar{x}$ = 3.0 and 2.9).

Finally, with regard to instructor capability to manage BT33 display presentations, the instructors on the whole felt fairly well in control. The mean response to question 8 was 3.4, with 90% indicating that no specific problems exist.

Operator Evaluation. This questionnaire is presented in appendix A. Operator responses are discussed in the following paragraphs.

a. Questionnaire items 1 through 4.

The first four items asked the operator for ratings, yes/no responses, and opinions regarding the operability of the BT33. The mean ratings for items 1 through 3 are given in Table 19. In discussing the issue of how easy it is to damage the equipment, it was pointed out that the target and sound track tapes were very easy to damage or tear, and that projector fan belts and firing battery buttons came apart easily.

Table 19

Operator Evaluation Questionnaire
Mean Responses (N = 3)

Questionnaire item	Mean rating
Equipment operation:	
1. Overall ease of operation	4.0*
2. Performance error avoidance	3.9
3. Equipment damage avoidance	2.4
Operator background:	
5. Electronic background required	1.7**
6. Forward observer background required	2.7

*Items 1 through 3 rated on a 5-point scale with 1.0 = poorest rating and 5.0 = best rating possible.

**Items 5 and 6 rated on a 5-point scale with 1.0 = very little and 5.0 = a great deal.

In responding to item 4, "Are there any other specific problems in the layout or operation of the device?," two of the three operators answered yes. The problems mentioned were that the unit should be more compact and that the projectors were difficult to service and align due to location.

b. Questionnaire items 5 and 6.

Items 5 and 6 concerned the amount of electronic equipment and FO background required to become a BT33 operator. As can be seen from Table 19, the operators felt that little electronic background was needed, but that a moderate FO procedures and map reading background would be helpful. Comments were to the effect that a 6 months' background in the 13E MOS was desirable.

c. Questionnaire items 7 and 8.

These items address the questions of how much training and practice is needed to become an operator and then maintain proficiency. The operators indicated that 2 to 5 days ($\bar{x}$ = 3) classroom training was needed and 1 to 5 days ($\bar{x}$ = 4) OJT. Two of the operators thought that once a month operation was sufficient to maintain proficiency, while the third operator felt that, given 2 months' experience on the equipment first, once a week was necessary.

DETAILED CONCLUSIONS

The conclusions of the study are discussed in terms of the questions presented in the Analysis Procedures section.

a. What is the demonstrated relative training effectiveness of the BT33 for live-fire FO missions?

The differences in performance on the criterion events did not, except in 3 cases out of 18, significantly differ as a function of experimental condition (see Table 2). Given that, it can be said that, overall, the seven experimental training programs with the BT33 are as good as the current training program. Experimental conditions 4 and 5 (SSX and SXS) tend to produce slightly better training overall (RE_k = 1.20 and 1.19, while experimental conditions 2 and 8 (XSX and XXX, the current program) tend to produce the poorest training overall (RE_k = .98 and 1.00) (see Table 14). Programs 6 and 7 (XSS and SSS) tend to be intermediately effective (RE_k = 1.10 and 1.12) and are the most cost effective due to the reduction of live-fire and ammunition costs.

b. What is the judged relative training effectiveness of the BT33 for live-fire FO missions?

The FAOBC and FAOAC students gave the BT33 fairly high ratings for early procedures and communications skills training (see Tables 15 and 17). The BT33 was rated as somewhat less than moderately effective for visual/perceptual skills training, however, and short-term problems were noted upon transition to the field environment. This visual problem may be the reason for the lower RE value obtained on Mobile Shoot One (see Table 14). The fact that the RE values for the final two graded events were higher substantiates the judgments that

the transition problems were indeed short-lived and negates the importance of the problem given some field training in live fire.

The instructors judged the BT33 to be moderately effective overall and for three groups of students: FAOBC, AIT, and MASOC (see Table 18). They judged it as less than moderately effective for the FAOAC and unit students. The implications of the latter two exceptions for OFT are not clear for two reasons:

1. The FAOAC students, in contrast to their instructors, gave the BT33 even higher ratings than did the FAOBC students. This difference of opinion, based on a very small N in the case of the instructors (N = 5), may give greater weight to the higher rating given by the students.

2. The BT33 is not designed for the field environment, whereas OFT will be.

It is not known whether the instructors were rating the BT33 in terms of its field environment suitability or in terms of its likely unit training effectiveness.

The conclusions to be derived here are two. One, the BT33 is judged to be effective in the institutional training environment, so long as the need for adequate live-fire training continues to be recognized. Two, the instructors should be assessed again regarding their views concerning the value of the OFT in the unit environment. If doubts really exist then it might be well to extend the OFT CTEA evaluation to the unit environment when the LRIP OFT models are received.

c. Are the training programs differentially effective for students of different aptitude levels?

Results of the ANOVAs indicate that the eight experimental programs were differentially effective based on aptitude differences for 7 out of 30 data points. The interaction between experimental condition and aptitude was significant on three out of five events for the Total Cuts Score, two events for Total Mission Time, and one event for Accuracy of Initial Target Location (see Table 1). The significant interactions show that the individual programs produced different performance results for subjects of high versus low aptitudes, but the relationships between the STEP score and performance were not consistent.

A more detailed examination was also conducted to determine if the BT33 is itself differentially effective for different aptitudes as compared to the current training environments. The relationships between STEP score and performance, as assessed by the correlation coefficient, were examined for each individual training event x experimental condition situation. Again, no consistent relationships were found.

d. How well is the BT33 designed from a human factors standpoint?

The operator and instructor judgments indicated that the BT33 is designed fairly well from an operability standpoint but not so well from a maintainability standpoint (see Tables 18 and 19). Specific problems are discussed on pp. 39-41.

e. How well does the BT33 facilitate instruction as compared to training events consisting of live fire?

The BT33 appears to facilitate instruction at least moderately well in terms of student learning speed, instructor-student interactions, and diagnosis of student learning problems (see Table 18). Further, it was determined that a BT33 mission takes an average of 8.5 minutes, as compared to 15.2 minutes for a live-fire mission; i.e., it takes 44% less time to shoot a mission in the BT33 than in the field. Hence either students can shoot more missions, thus receiving more practice, or the class time could be cut. The latter option should not be employed however without careful testing to insure that adequate training would still be received.

f. To what extent do students and instructors want to use the BT33 for training purposes?

Based on their comments and evaluations regarding training effectiveness, plus the desire evidenced by both the FAOBC and FAOAC students for additional time on the BT33 outside of class (see Tables 15 and 17), it appears that the majority of students do want to use the BT33 to at least some extent. The instructors indicated that 20% to 22% of the FO training could well take place in the BT33.

Overall, it appears that most students will accept the BT33 at least to the extent that the instructors do. The principal concern of the students is obtaining a high score in the graded events. If they are reassured that their overall grade average will be as high if they use the BT33, using the findings of this study as evidence, even more students will accept the BT33 positively.

g. Can the BT33 be useful in student evaluation?

Almost half of the instructors felt that student performance in the BT33 could be validly evaluated, primarily with regard to procedural skills.

APPENDIX A

QUESTIONNAIRES

USAFAS BT33 TRAINING EFFECTIVENESS STUDY
STUDENT EVALUATION
FAOBC CLASSES

FOR ADP USE ONLY

The USAFAS, with the assistance of the Army Research Institute, is evaluating the utility of the BT33 Fire Control Simulator for Forward Observer training. It is a Swedish training device, built by Saab-Scania. It is comparable in many ways to the Army's own Observed Fire Trainer, which is now under development.

As an aid in evaluating the impact of this training device on the student and how it might best be used, please fill out this cover sheet and the attached questionnaire as completely as you can. Your answers will be used for research purposes only and will not become a part of your record. When identifiers (name and Social Security Account Number) are requested they are to be used for administrative and statistical control purposes only. Full confidentiality of the responses will be maintained in the processing of these data.

Your participation in this research is strictly voluntary. Individuals are encouraged to provide complete and accurate information in the interests of this equipment evaluation, but there will be no effect on individuals for not providing all or any part of the information. In keeping with the Privacy Act of 1974, we request that you sign your name at the bottom of the cover sheet indicating that you have not objected to completing this form.

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CLASS (e.g., FAOBC 9-76) _____ SECTION _____

DATE _____

NAME _____
Last First MI

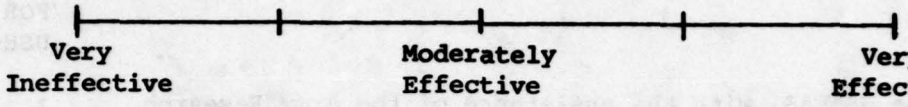
1. Time as a commissioned officer (months) _____

2. Source of commission (check one): BIOCC _____ USMA _____
ROTC _____

SIGNATURE _____

In several of the questions you will be asked to evaluate some characteristic of the BT33 through use of a rating scale. Please regard these scales as being continuous. Place an "x" at whatever location on the scale best describes your opinion.

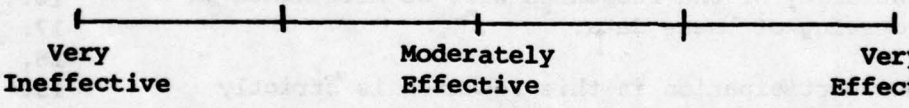
1. Overall, how effective do you feel the BT33 is as a training device?



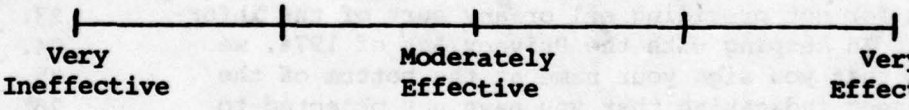
2. Performance of the Forward Observer's job involves the use of procedural, communications, and visual/perceptual skills. In answering the following questions, think about what you learned and the manner of performance of each of these in the BT33 training environment vs. out on the range during live firing exercises.

   a. How effective do you feel the BT33 is for training each of these skills:

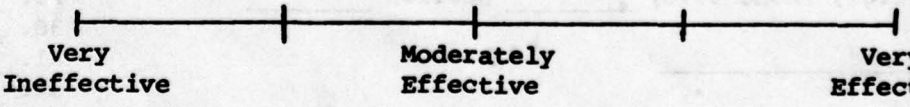
Procedural?



Communications?



Visual/Perceptual?



b. Were there any differences in the manner of your performance in the BT33 vs. range environments which caused you difficulty when performing on the range?

Procedural differences? Yes _____
No _____

If the above answer was "Yes," please describe the differences and indicate whether the difficulty you experienced was very short-term or lasted for some longer period of time.

Communications differences? Yes _____
No _____

If the above answer was "Yes," please describe the differences and indicate whether the difficulty you experienced was very short-term or lasted for some longer period of time.

Visual/Perceptual differences? Yes _____
No _____

If the above answer was "Yes," please describe the differences and indicate whether the difficulty you experienced was very short-term or lasted for some longer period of time.

c. If any of the answers in 2b above were "Yes," please discuss what changes might be made in the use of the BT33 so as to resolve the problem.

Procedural differences:

Communications differences:

Visual/Perceptual differences:

3. Overall, how do the BT33 and Puff Board training devices compare to a live fire training exercise for training effectiveness? (If you were not exposed to the Puff Board please skip that part of the evaluation.)

Puff Board:

Much Less Effective — Same — More More Effective

BT33 Training Device:

Much Less Effective — Same — Much More Effective

4. Now more specifically, how does the BT33 compare to live fire exercises for training effectiveness at different points in training?

a. The very first practice session (known as the "Puffboard" exercise). How does the BT33 compare to a live fire exercise for training effectiveness on this session?

Much Less Effective — Same — Much More Effective

b. Daly Hill exercise. (Compare the BT33 to the Daly Hill situation for training effectiveness.)

Much Less Effective — Same — Much More Effective

c. Arbuckle Hill exercise.

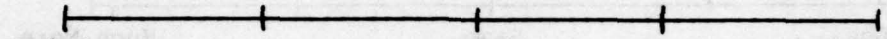
Much Less Effective — Same — Much More Effective

d. Bunker Hill Shoot.

Much Less Effective — Same — Much More Effective

Do you think a realistic evaluation of your skills could be made in the BT33 rather than at Bunker Hill? Yes ____ No ____

e. Mobile Shoot One.



Much Less Effective — Same — Much More Effective

f. Mobile Shoot Two.

Much Less Effective — Same — Much More Effective

g. Are there any other FAOBC field exercises where the BT33 might be an effective substitute?

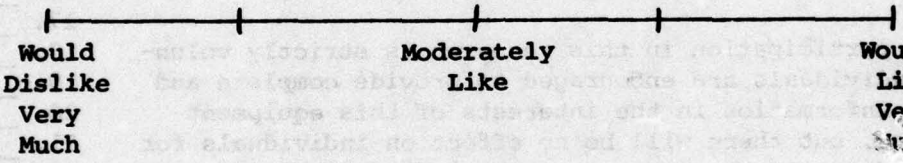
5. Do you have any recommendations for improvement of BT33 training effectiveness with respect to any of the following?

a. Terrain, target, or burst presentations?

b. The manner in which the BT33 is used by the instructors?

c. Anything else?

6. Would you like to have the BT33 available to you for additional practice outside of the presently scheduled class training sessions?



USAFAS BT33 TRAINING EFFECTIVENESS STUDY
STUDENT EVALUATION

FAOAC, MASOC, AIT AND III CORPS ARTILLERY

The USAFAS, with the assistance of the Army Research Institute, is evaluating the utility of the BT33 Fire Control Simulator for Forward Observer training. It is a Swedish training device, built by Saab-Scania. It is comparable in many ways to the Army's own Observed Fire Trainer, which is now under development.

As an aid in evaluating the impact of this training device on the student and how it might best be used, please fill out this cover sheet and the attached questionnaire as completely as you can. Your answers will be used for research purposes only and will not become a part of your record. When identifiers (name and Social Security Account Number) are requested they are to be used for administrative and statistical control purposes only. Full confidentiality of the responses will be maintained in the processing of these data.

Your participation in this research is strictly voluntary. Individuals are encouraged to provide complete and accurate information in the interests of this equipment evaluation, but there will be no effect on individuals for not providing all or any part of the information. In keeping with the Privacy Act of 1974, we request that you sign your name at the bottom of the second cover sheet indicating that you have not objected to completing this form.

CLASS (e.g., FAOBC 9-76) _____ SECTION _____

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NAME _____ SSAN _____
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FOR ADP USE ONLY

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1. Officer _____ Enlisted _____ (check one)

2. Rank _____

3. Time in the military _____months

4. Prior enlisted service _____months

5. Source of commission (check one if applicable): BIOCC ____ USMA ____
ROTC ____

6. Have you ever served as an FO? Yes ___ No ___

How long _____months In combat? Yes___ No ___

7. How many missions have you fired since OBC/OCS? (estimate) _____

8. Which program are you currently enrolled in? (check one)

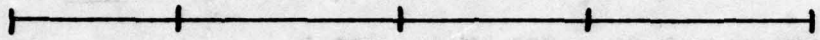
FAOAC _____ MASOC _____ AIT _____ III Corps Artillery _____

NOTE: PLEASE RESPOND TO THIS QUESTIONNAIRE REGARDING THE BT33 ONLY IN TERMS OF ITS POTENTIAL USE WITHIN THE PROGRAM YOU ARE CURRENTLY IN.

SIGNATURE _____

In several of the questions you will be asked to evaluate some characteristic of the BT33 through use of a rating scale. Please regard these scales as being continuous. Place an "x" at whatever location on the scale best describes your opinion.

1. Overall, how effective do you feel the BT33 is as a training device?

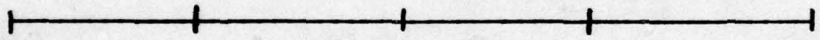


Very Ineffective | Moderately Effective | Very Effective

2. Performance of the Forward Observer's job involves the use of procedural, communications, and visual/perceptual skills. In answering the following questions, think about what you learned and the manner of performance of each of these in the BT33 training environment vs. out on the range during live firing exercises.

   a. How effective do you feel the BT33 is for training each of these skills?

<u>Procedural</u>?



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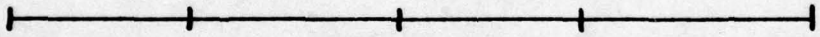
<u>Communications</u>?



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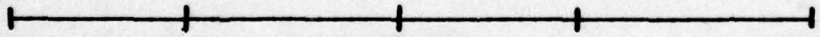
<u>Visual/Perceptual</u>?



Very Ineffective | Moderately Effective | Very Effective

b. Were there any differences in the manner of your performance in the BT33 vs. range environments which caused you difficulty when performing on the range?

Procedural differences? Yes ____
No ____

If the above answer was "Yes," please describe the differences and indicate whether the difficulty you experienced was very short-term or lasted for some longer period of time.

Communications differences? Yes ____
No ____

If the above answer was "Yes," please describe the differences and indicate whether the difficulty you experienced was very short-term or lasted for some longer period of time.

Visual/Perceptual differences? Yes ____
No ____

If the above answer was "Yes," please describe the differences and indicate whether the difficulty you experienced was very short-term or lasted for some longer period of time.

c. If any of the answers in 2b above were "Yes," please discuss what changes might be made in the use of the BT33 so as to resolve the problem.

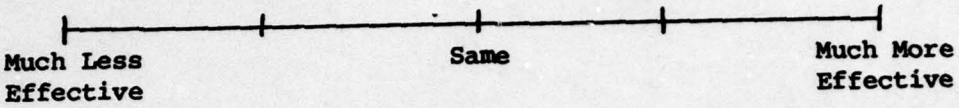
Procedural differences:

Communications differences:

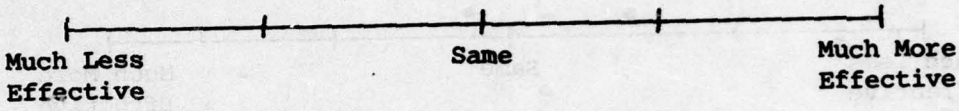
Visual/Perceptual differences:

3. Overall, how do the BT33 and Puff Board training devices compare to a live fire training exercise for training effectiveness? (If you were not exposed to the Puff Board please skip that part of the evaluation.)

Puff Board:

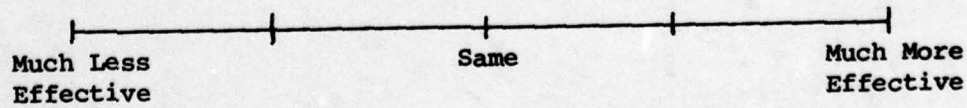


BT33 Training Device:



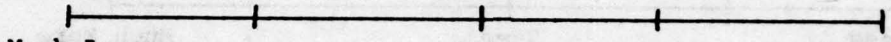
4. Now more specifically, how does the BT33 compare to live fire exercises for training effectiveness at different points in training? And in different training programs (e.g., FAOAC vs. AIT)? Make evaluations for all of those programs in which you have actually participated as well as the one you are currently in.

FAOAC a. How does the BT33 compare to live fire exercises for training effectiveness within the FAOAC program? (Answer only if you are or have been in the FAOAC.)



FAOAC b. How often and in what manner do you think the BT33 might be best used in the FAOAC?

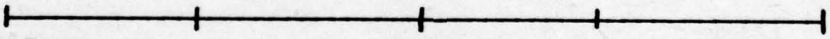
AIT c. How does the BT33 compare to live fire exercises for training effectiveness in the AIT program? (Answer only if you are or have been in AIT.)



Much Less Effective — Same — Much More Effective

AIT d. How often and in what manner do you think the BT33 might be best used in the AIT program?

MASOC e. How does the BT33 compare to live fire exercises for training effectiveness in the MASOC program? (Answer only if you are in MASOC.)

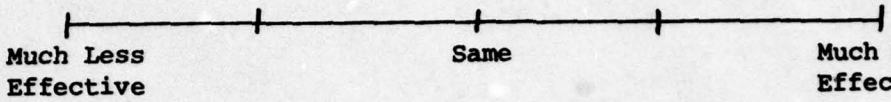


Much Less Effective — Same — Much More Effective

MASOC f. How often and in what manner do you think the BT33 might be best used in the MASOC program?

III Corps Artillery

g. How does the BT33 compare to live fire exercises for refresher training effectiveness? (Answer only if you are a member of the III Corps Artillery.)



III Corps Artillery

h. How often and in what manner do you think the BT33 might be best used for refresher training?

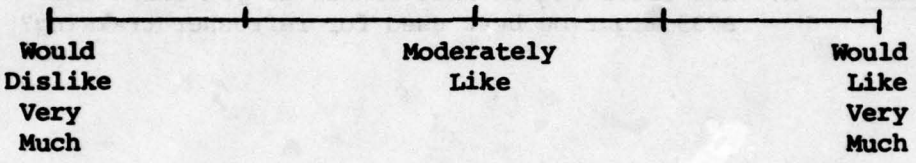
5. Do you have any recommendations for improvement of BT33 training effectiveness with respect to any of the following?

a. Terrain, target, or burst presentations?

b. The manner in which the BT33 is used by the instructors?

c. Anything else?

6. Would you like to have the BT33 available to you for additional practice outside of the presently scheduled class training sessions?



USAFAS BT33 TRAINING EFFECTIVENESS STUDY
INSTRUCTOR EVALUATION

FOR ADP USE ONLY

The USAFAS, with the assistance of the Army Research Institute (ARI), is evaluating the utility of the BT33 Fire Control Simulator for Forward Observer training. It is a Swedish training device, built by SAAB-Scania. It is comparable in many ways to the Army's own Observed Fire Trainer, which is now under development.

As an aid in evaluating the characteristics and utility of this training device as an instructional tool, please fill out this cover sheet and the attached questionnaire as completely as you can. Your answers will be used for research purposes only and will not become a part of your record. When identifiers (name and Social Security Account Number) are requested they are to be used for administrative and statistical control purposes only. Full confidentiality of the responses will be maintained in the processing of these data.

Your participation in this research is strictly voluntary. Individuals are encouraged to provide complete and accurate information in the interests of this equipment evaluation, but there will be no effect on individuals for not providing all or any part of the information. In keeping with the Privacy Act of 1974, we request that you sign your name at the bottom of the second cover sheet indicating that you have not objected to completing this form.

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
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9. _____
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11. _____
12. _____
13. _____
14. _____
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17. _____
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19. _____
20. _____
21. _____
22. _____
23. _____
24. _____
25. _____
26. _____
27. _____
28. _____
29. _____

NAME _____
Last First MI

DATE _____ SSAN _____

INSTRUCTOR POOL MEMBERSHIP: ____ FAOBC ____ FAOAC

NOTE: Please respond to this questionnaire only in terms of your own current teaching background (i.e., FAOBC or FAOAC).

1. Time as a commissioned officer: _____Months

2. Source of commission (check one): BIOCC _____ USMA _____
ROTC _____

3. Prior enlisted service? _____Months

4. Have you completed the FAOAC? _____Yes _____No

5. Have you served as a FO? _____

How long? _____Months In combat? _____Yes _____No

6. How many missions have you fired since OBC/OCS (estimate)? _____

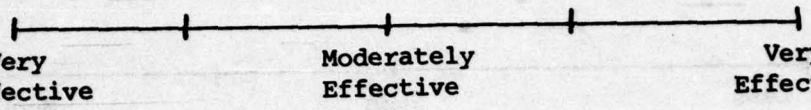
7. How long have you been an instructor? _____Months

8. How many classes have you handled? _____

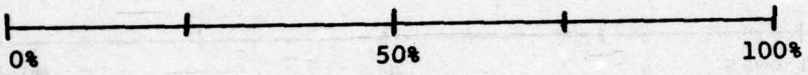
SIGNATURE _____

In several of the questions you will be asked to evaluate some characteristic of the BT33 through use of a rating scale. Please regard these scales as being continuous. Place an "x" at whatever location on the scale best describes your opinion.

1. Overall, how effective do you feel the BT33 is as a training device?



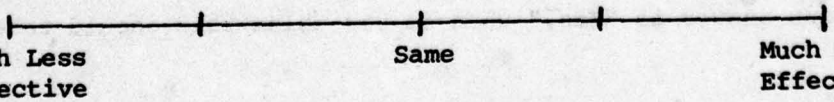
2. For FAOBC ____ (check one) training, what percent of the
FAOAC ____
practice exercises do you think could take place in the BT33?



3. For FAOBC ____ (check one) training, when in the training schedule
FAOAC ____
do you think the BT33 could best be used (e.g., for the first, third and fifth practice exercises, or .....)?

4. Compare the training effectiveness of the BT33 environment vs. out on the range. How would you evaluate the effectiveness of the BT33, as compared to a live fire exercise, with respect to the following parameters and conditions?

a. How <u>well</u> the student learns his skills?



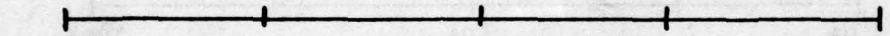
b. How quickly the student learns his skills?

Much Less Effective — Same — Much More Effective

c. For ____ FAOBC (check one) training?
____ FAOAC

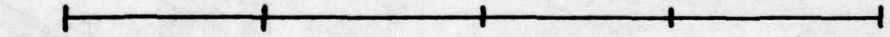
Much Less Effective — Same — Much More Effective

d. For AIT training? (Respond only if you have instructed an AIT class.)



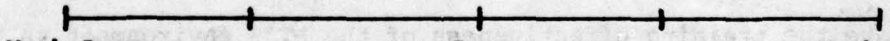
Much Less Effective — Same — Much More Effective

e. For MASOC training? (Respond only if you have instructed an MASOC class.)



Much Less Effective — Same — Much More Effective

f. For Forward Observer training in the field?

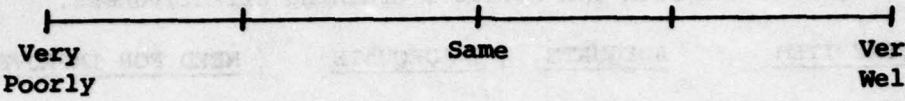


Much Less Effective — Same — Much More Effective

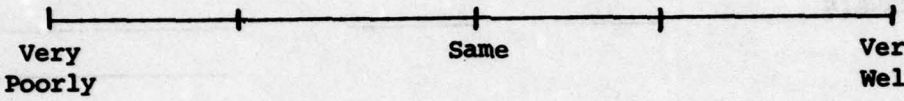
5. Do you think any student performance evaluation could be done in the BT33? Yes ____ No ____

If your answer is "Yes," when do you think this should take place?

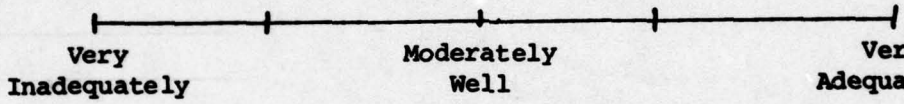
6. As compared to the live fire exercise situation, how well does the BT33 environment facilitate instructor-student interaction?



7. As compared to the live fire exercise situation, how well does the BT33 environment enable you to identify the nature of student performance problems and misunderstandings?



8. How adequately can you manage the BT33 display presentations?



Do you have any specific problems in managing the presentations?
Yes ____ No ____

If your answer was "Yes," please describe the problems:

9. Consider the fidelity of BT33 display presentations and the variety of situations you can create. Please make a judgment of device adequacy and identify any needs for improvement, which, if made, would improve the device's training effectiveness.

DISPLAY ITEM	ADEQUATE	INADEQUATE	NEED FOR IMPROVEMENT
TARGETS	_____	_____	_____
	(Check one)		_____
			_____
TERRAIN	_____	_____	_____
			_____
			_____
BURSTS	_____	_____	_____
			_____
			_____
OTHER: _____	_____	_____	_____
_____			_____
			_____

10. Do you have any other recommendations for improvement of either the BT33 itself or the manner in which it is used?

USAFAS BT33 TRAINING EFFECTIVENESS STUDY
OPERATOR EVALUATION

The USAFAS, with the assistance of the Army Research Institute (ARI), is evaluating the utility of the BT33 Fire Control Simulator for Forward Observer training. It is a Swedish training device, built by Saab-Scania. It is comparable in many ways to the Army's own Observed Fire Trainer, which is now under development.

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Your participation in this research is strictly voluntary. Individuals are encouraged to provide complete and accurate information in the interests of this equipment evaluation, but there will be no effect on individuals for not providing all or any part of the information. In keeping with the Privacy Act of 1974, we request that you sign your name at the bottom of the cover sheet indicating that you have not objected to completing this form.

NAME _____
Last First MI

DATE _____ SSAN _____

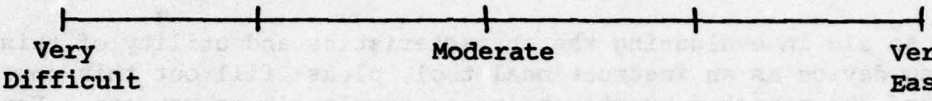
MOS _____ TIME IN THIS MOS _____Months

GRADE _____ TIME IN SERVICE _____Months

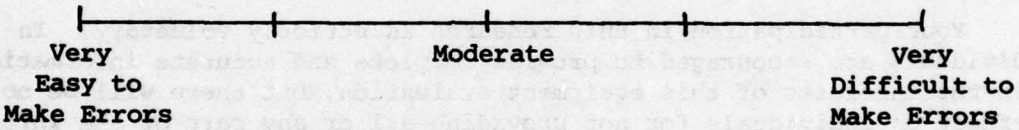
SIGNATURE _____

Many of the questions will ask that you rate the BT33 on some characteristic through use of a rating scale. Please consider the scales to be continuous ones. Place an "x" on the scale at whatever location best describes your opinion.

1. Compared to other similar devices you have worked with, how easy is the BT33 to operate overall?



2. Is it easy or difficult to make errors in the operation of the BT33? I.e., how precise and careful do you always have to be in order to avoid making errors?



If any operational errors can be easily made, would you please describe what these are?

3. Is it easy or difficult to avoid damage to the equipment when operating the BT33?

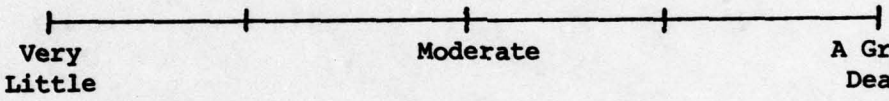
If any items of BT33 equipment can be rather easily damaged during operations, would you please indicate what these are?

4. Are there any other specific problems in the layout or operation of the device?

Yes _____
No _____

If your answer was "Yes," please describe these problems.

5. In the selection of personnel to become BT33 operators, how much <u>electronic equipment</u> background experience do you think they should have?



Would you please describe the desirable background for a BT33 operator in terms of MOS, amount of MOS experience, grade, etc.?

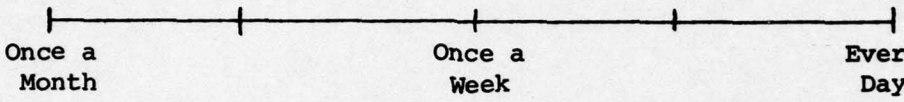
6. In the selection of personnel to become BT33 operators, how much <u>forward observer</u> background experience do you think they should have?

Would you please describe the desirable FO background in terms of programs (e.g., AIT) and operational time?

7. How many days of classroom and on-the-job training do you feel a person would have to have before he would be a qualified BT33 operator?

Classroom _____days
OJT _____days

8. How frequently do you feel a person would have to perform as a BT33 operator to maintain his operator proficiency?



Please describe the above frequency in words (e.g., one week out of four, once a week, etc.).

9. From an operator's standpoint, do you have any recommendations for the improvement of the BT33?

Table B-1

A Summary of Raw Data Subject Ns and Mean Scores on the Time to Locate Target (Seconds) Measure for the Immediate Suppression-Grid Coordinates Data Subgroup

	Training events		Criterion events		
Experimental conditions	Daly Hill	Arbuckle Hill	Mobile Shoot One	Bunker Shoot	Mobile Shoot Two
#1 (SXX)	5* 40**	7 39	20 23	7 24	10 25
#2 (XSX)	1 17	3 23	18 28	2 31	3 17
#3 (XXS)	- - - - -	2 25	17 28	4 24	6 28
#4 (SSX)	2 36	4 40	10 33	2 19	2 28
#5 (SXS)	- - - - -	2 36	3 29	1 18	1 10
#6 (XSS)	1 41	4 28	5 45	4 30	8 23
#7 (SSS)	2 64	3 31	6 27	2 18	6 24
#8 (XXX)	5 30	15 30	36 26	5 20	21 25

*Subject N.
**Mean performance score.

Table B-2

A Summary of Raw Data Subject Ns and Mean Scores on the Total Mission Time (Seconds) Measure for the Immediate Suppression-Grid Coordinates Data Subgroup

	Training events		Criterion events		
Experimental conditions	Daly Hill	Arbuckle Hill	Mobile Shoot One	Bunker Shoot	Mobile Shoot Two
#1 (SXX)	5* 1237**	7 328	18 265	7 360	10 179
#2 (XSX)	1 120	3 781	16 270	1 302	3 220
#3 (XXS)	- - - - -	2 150	17 262	3 362	6 464
#4 (SSX)	2 181	4 347	8 520	2 273	2 363
#5 (SXS)	1 480	2 960	3 284	1 241	1 423
#6 (XSS)	1 302	4 182	5 219	4 421	8 223
#7 (SSS)	2 213	3 182	6 264	2 122	6 405
#8 (XXX)	5 289	12 462	34 261	5 170	21 237

*Subject N.
**Mean performance score.

Table B-3

A Summary of Raw Data Subject Ns and Mean Scores on the Accuracy of Initial Target Location (Radial Error, Meters) Measure for the Immediate Suppression-Grid Coordinates Data Subgroup

	Training events		Criterion events		
Experimental conditions	Daly Hill	Arbuckle Hill	Mobile Shoot One	Bunker Shoot	Mobile Shoot Two
#1 (SXX)	5 97	7 135	21 342	7 118	10 199
#2 (XSX)	1 0	3 507	18 224	2 255	3 80
#3 (XXS)	- - - - -	4 484	17 278	4 349	6 435
#4 (SSX)	2 100	5 261	11 377	2 50	2 241
#5 (SXS)	1 500	3 653	3 258	1 100	1 200
#6 (XSS)	1 671	4 106	5 334	4 286	8 312
#7 (SSS)	2 71	3 2067	6 193	2 271	6 308
#8 (XXX)	5 403	16 297	37 183	5 178	21 285

*Subject N.
**Mean performance score.

Table B-4

A Summary of Raw Data Subject Ns and Mean Scores on the Number of Rounds Fired Measure for the Immediate Suppression-Grid Coordinates Data Subgroup

Experimental conditions	Training events		Criterion events		
	Daly Hill	Arbuckle Hill	Mobile Shoot One	Bunker Shoot	Mobile Shoot Two
#1 (SXX)	5* 2.8**	7 1.9	23 2.1	7 1.6	10 1.6
#2 (XSX)	1 1.0	3 2.3	19 1.8	2 2.5	3 1.3
#3 (XXS)	- - - - -	4 3.2	17 2.3	4 1.8	6 2.5
#4 (SSX)	2 2.0	5 3.0	11 2.8	2 2.0	2 2.5
#5 (SXS)	2 2.0	3 4.0	3 2.0	1 2.0	1 3.0
#6 (XSS)	1 3.0	3 3.7	5 2.6	4 2.0	8 2.1
#7 (SSS)	2 6.0	3 5.3	6 2.2	2 2.0	6 2.6
#8 (XXX)	5 1.6	16 1.9	37 2.2	5 2.6	21 2.0

*Subject N.
**Mean performance score.

Table B-5

A Summary of Raw Data Subject Ns and Mean Scores on the Procedural Errors Cut Score Measure for the Immediate Suppression-Grid Coordinates Data Subgroup

	Training events		Criterion events		
Experimental conditions	Daly Hill	Arbuckle Hill	Mobile Shoot One	Bunker Shoot	Mobile Shoot Two
#1 (SXX)	5* 4.8**	7 1.7	23 7.8	7 2.6	10 3.4
#2 (XSX)	1 0.0	3 21.7	19 5.3	2 7.0	3 1.3
#3 (XXS)	- - - - -	4 7.5	17 8.0	4 9.8	6 12.7
#4 (SSX)	2 0.0	5 7.4	11 8.3	2 6.4	2 7.0
#5 (SXS)	2 28.5	3 9.0	3 11.2	1 13.0	1 0.0
#6 (XSS)	1 15.0	4 13.8	5 12.9	4 5.0	8 7.5
#7 (SSS)	2 16.0	3 3.0	6 7.0	2 2.5	6 10.2
#8 (XXX)	5 8.0	17 7.1	37 6.4	5 9.8	21 6.5

*Subject N.
**Mean performance score.

Table B-6

A Summary of Raw Data Subject Ns and Mean Scores on the Total Cuts Score Measure for the Immediate Suppression-Grid Coordinates Data Subgroup

	Training events		Criterion events		
Experimental conditions	Daly Hill	Arbuckle Hill	Mobile Shoot One	Bunker Shoot	Mobile Shoot Two
#1 (SXX)	5* 15.2**	7 7.9	23 10.5	7 4.0	10 10.5
#2 (XSX)	1 0.0	3 29.7	19 10.5	2 18.5	3 1.3
#3 (XXS)	- - - - -	4 22.8	17 12.5	4 18.8	6 23.5
#4 (SSX)	2 0.0	5 20.6	11 17.0	2 4.5	2 24.5
#5 (SXS)	2 33.5	3 22.3	3 12.6	1 15.0	1 10.0
#6 (XSS)	1 25.0	4 19.5	5 17.5	4 22.5	8 12.7
#7 (SSS)	2 16.0	3 18.0	6 14.0	2 20.0	6 20.9
#8 (XXX)	5 9.2	17 12.8	37 11.0	5 12.4	21 11.9

*Subject N.
**Mean performance score.

APPENDIX C

RE_{ijk} VALUES

Table C-1

RE_{ijk}, RE_{jk}, and RE_k Values for Experimental Condition Number One (SXX)

Performance measures	Events		
	Mobile Shoot One	Bunker Shoot	Mobile Shoot Two
Time to Locate Target	1.09	1.00	1.00
Total Mission Time	.94	.61	.96
Accuracy of Initial Target Location	.92	.93	1.27
Number of Rounds Fired	1.02	1.21	1.06
Procedural Errors Cut Score	.91	2.12	.75
Total Cuts Score	1.01	2.69	1.13
RE_{jk}, k=1	.98	1.43	1.03
RE_k, k=1			1.11

Table C-2

RE_{ijk}, RE_{jk}, and RE_k Values for Experimental Condition Number Two (XSX)

Performance measures	Events		
	Mobile Shoot One	Bunker Shoot	Mobile Shoot Two
Time to Locate Target	.95	.96	1.11
Total Mission Time	1.02	2.20	1.13
Accuracy of Initial Target Location	.83	.35	1.01
Number of Rounds Fired	.90	.76	1.36
Procedural Errors Cut Score	.74	.57	.86
Total Cuts Score	.71	.80	1.28
RE_{jk}, k=2	.86	.94	1.13
RE_k, k=2			.98

Table C-3

RE_{ijk}, RE_{jk}, and RE_k Values for Experimental Condition Number Three (XXS)

Performance measures	Events		
	Mobile Shoot One	Bunker Shoot	Mobile Shoot Two
Time to Locate Target	1.17	1.18	.94
Total Mission Time	1.33	1.47	.80
Accuracy of Initial Target Location	1.01	1.34	1.05
Number of Rounds Fired	.96	1.27	1.04
Procedural Errors Cut Score	1.00	.67	.87
Total Cuts Score	.84	1.40	1.14
RE_{jk}, k=3	1.05	1.22	.97
RE_k, k=3			1.08

Table C-4

RE_{ijk}, RE_{jk}, and RE_k Values for Experimental Condition Number Four (SSX)

Performance measures	Events		
	Mobile Shoot One	Bunker Shoot	Mobile Shoot Two
Time to Locate Target	1.03	.76	.94
Total Mission Time	.99	.93	1.11
Accuracy of Initial Target Location	1.21	1.14	1.64
Number of Rounds Fired	1.00	1.07	1.10
Procedural Errors Cut Score	1.13	1.85	.83
Total Cuts Score	.98	2.24	1.71
RE_{jk}, k=4	1.06	1.33	1.22
RE_k, k=4			1.20

Table C-5

RE_{ijk}, RE_{jk}, and RE_k Values for Experimental Condition Number Five (SXS)

Performance measures	Events		
	Mobile Shoot One	Bunker Shoot	Mobile Shoot Two
Time to Locate Target	1.67	1.53	1.15
Total Mission Time	1.58	1.51	1.12
Accuracy of Initial Target Location	.52	1.78	1.61
Number of Rounds Fired	.84	.81	1.06
Procedural Errors Cut Score	.57	.84	1.42
Total Cuts Score	.71	.77	1.99
RE_{jk}, k=5	.98	1.21	1.39
RE_k, k=5			1.19

Table C-6

RE_{ijk}, RE_{jk}, and RE_k Values for Experimental Condition Number Six (XSS)

Performance measures	Events		
	Mobile Shoot One	Bunker Shoot	Mobile Shoot Two
Time to Locate Target	1.03	1.00	1.03
Total Mission Time	.83	.66	1.16
Accuracy of Initial Target Location	.87	.54	1.21
Number of Rounds Fired	.84	.81	1.14
Procedural Errors Cut Score	1.19	3.60	.94
Total Cuts Score	.84	.66	1.53
RE_{jk}, k=6	.93	1.21	1.17
RE_k, k=6			1.10

Table C-7

RE_{ijk}, RE_{jk}, and RE_{k} Values for Experimental Condition Number Seven (SSS)

Performance measures	Events		
	Mobile Shoot One	Bunker Shoot	Mobile Shoot Two
Time to Locate Target	.92	1.08	1.20
Total Mission Time	.91	1.06	1.29
Accuracy of Initial Target Location	1.33	.86	1.21
Number of Rounds Fired	1.04	1.43	.98
Procedural Errors Cut Score	.87	1.00	1.49
Total Cuts Score	.98	.83	1.74
RE_{jk}, k=7	1.01	1.04	1.32
RE_{k}, k=7			1.12

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