AD A119053

Technical Report 521

VALIDATION OF TANK GUNNERY TRAINING TASKS

Gary Kress
Human Resources Research Organization

ARI FIELD UNIT IN USAREUR

DTIC
ELECTE
SEP 8 1982
S D
H

DTIC FILE COPY

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

September 1981

82 08 06 033

Approved for public release; distribution unlimited.

U. S. ARMY RESEARCH INSTITUTE
FOR THE BEHAVIORAL AND SOCIAL SCIENCES

A Field Operating Agency under the Jurisdiction of the

Deputy Chief of Staff for Personnel

JOSEPH ZEIDNER
Technical Director

L. NEALE COSBY
Colonel, IN
Commander

Research accomplished under contract
for the Department of the Army

HUMAN RESOURCES RESEARCH ORGANIZATION

NOTICES

DISTRIBUTION: Primary distribution of this report has been made by ARI. Please address correspondence concerning distribution of reports to: U.S. Army Research Institute for the Behavioral and Social Sciences, ATTN: PERI-TST, 5001 Eisenhower Avenue, Alexandria, Virginia 22333.

FINAL DISPOSITION: This report may be destroyed when it is no longer needed. Please do not return it to the U.S. Army Research Institute for the Behavioral and Social Sciences.

NOTE: The findings in this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER
Technical Report 521

2. GOVT ACCESSION NO.
AD-A119053

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)
VALIDATION OF TANK GUNNERY TRAINING TASKS

5. TYPE OF REPORT & PERIOD COVERED
Final Report: Sept. 1979-Sept. 1980

6. PERFORMING ORG. REPORT NUMBER
--

7. AUTHOR(s)
Gary Kress

8. CONTRACT OR GRANT NUMBER(s)
MDA 903-78-C-2042

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Human Resources Research Organization (HumRRO)
300 North Washington Street
Alexandria, VA 22314

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
2Q163744A795

11. CONTROLLING OFFICE NAME AND ADDRESS
U.S. Army Research Institute for the Behavioral and Social Sciences PERI-OI
5001 Eisenhower Avenue, Alexandria, VA 22333

12. REPORT DATE
September 1981

13. NUMBER OF PAGES
88

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)
U.S. Army Research Institute for the Behavioral and Social Sciences, USAREUR Field Unit
ODCSPER, HQ USAREUR, APO New York 09403

15. SECURITY CLASS. (of this report)
Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
--

16. DISTRIBUTION STATEMENT (of this Report)
Approved for public release; distribution unlimited.

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

18. SUPPLEMENTARY NOTES
--

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

Tank gunnery training	Personnel turbulence
Armor training	Performance measurement
Simulation based training	

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

Tank Commander and Gunner performance on nine critical tank gunnery training tasks, as well as experience measures were correlated with performance on Tank Gunnery Table VIII. Results showed that (a) performance on the subcaliber training range (1/60 scale cal. 22) was the best predictor of Table VIII performance, (b) there was no relationship between crew turbulence measures and gunnery performance, and (c) the Gunner's job experience was positively correlated with Table VIII performance.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

Technical Report 521

VALIDATION OF TANK GUNNERY TRAINING TASKS

Gary Kress
Human Resources Research Organization

Submitted by:
William W. Haythorn, Chief
ARI FIELD UNIT IN USAREUR

Approved by:

Cecil D. Johnson, Director
MANPOWER AND PERSONNEL
RESEARCH LABORATORY

U.S. ARMY RESEARCH INSTITUTE FOR THE BEHAVIORAL AND SOCIAL SCIENCES
5001 Eisenhower Avenue, Alexandria, Virginia 22333

Office, Deputy Chief of Staff for Personnel
Department of the Army

September 1981

Army Project Number
2Q163744A795

Training Simulation

Approved for public release; distribution unlimited.

ARI Research Reports and Technical Reports are intended for sponsors of R&D tasks and for other research and military agencies. Any findings ready for implementation at the time of publication are presented in the last 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

Research in the area of simulation-based training program development and field validation is a major effort of the Army Research Institute for the Behavioral and Social Sciences (ARI) USAREUR Field Unit. The entire project is directly responsive to the Army's advanced development RDTE program and to special requirements of the 7th Army Training Command at Grafenwoehr, Germany. This report describes research undertaken to determine the relationship between performance on simulation based tank gunnery training tasks and performance on live fire crew qualification tests.

The work reported here was performed at the Heidelberg Office of the Human Resources Research Organization (HumRRO), under Contract No. MDA 903-78-C-2042 with the US Army Research Institute for the Behavioral and Social Sciences (ARI). The research was monitored technically by Dr. William W. Haythorn as part of Army Project 2Q163744A795.

JOSEPH ZEIDNER
Technical Director

Accession For
NTIS GRA&I
DTIC TAB
Unannounced
Justification
By
Distribution/
Availability Codes
Dist | Avail and/or Special
A

DTIC COPY INSPECTED 2

ACKNOWLEDGEMENTS

The author wishes to express his appreciation to LTC Robert Garrott, Jr. and SFC George Cannon for their support and cooperation during the field data collection portion of this research effort. Kathy Ford of the ARI research staff and Malachi Fullard of the HumRRO research staff deserve special thanks for their tireless efforts in collecting data under sometimes adverse field conditions. Finally, special appreciation and gratitude is expressed to Wendy McGuire of the HumRRo staff for her many contributions during data collection, analysis, and report preparation.

VALIDATION OF TANK GUNNERY TRAINING TASKS

BRIEF

REQUIREMENT

To determine the empirical relationship between performance on critical crew Tank Gunnery Training Tasks and performance on Tank Gunnery Table VIII. To investigate the relationship between crew members' job experience and attitude measures and Table VIII performance.

PROCEDURE

Tank Commanders (TCs) and Gunners (GNRs) from 54 tank crews were tested on nine Tank Gunnery Training Tasks. The tasks ranged from basic skills (ability to select the correct sight picture for initial lay) to more complex performance (simulated engagements using subcaliber fire and a scaled range). Data were also collected on tank crew turbulence and TC and GNR job experience. Organizational Climate and Leadership questionnaires were administered to all crew members in the 54 tank crews.

Following the collection of the training task data, all crews participated in their annual live fire Tank Crew Qualification Test. Speed and accuracy performance measures were collected for Gunnery Table VIII. Table VIII performance measures were then correlated with each of the training task measures, turbulence and experience measures, and attitudinal measures.

FINDINGS

Performance on several training tasks was found to be significantly related to Table VIII gunnery performance. The Gunner's ability to hit moving targets on a simulation training task was positively related to accuracy on Table VIII. In addition, both speed and accuracy on a mini-tank training range (1/60 scale cal. 22) were positively correlated with speed and accuracy, respectively, on Table VIII. Multiple regression analysis showed that performance on the subcaliber training range was the best predictor of Table VIII performance. None of the individual measures of TC training performance correlated with Table VIII measures.

No relationship was found between tank crew turbulence and gunnery performance. The job experience of the Gunner in terms of length of time as a Gunner and prior experience with live fire gunnery were both positively correlated with Table VIII accuracy. No relationship was found between TC experience and Table VIII performance.

Finally, two Tank Commander attitude measures were significantly related to gunnery performance. The TC measures of group cohesion correlated positively with Table VIII accuracy while TC Leadership Consideration scores were negatively related to Table VIII speed measures.

UTILIZATION OF FINDINGS

The findings suggest that home station training on subcaliber mini-tank ranges is positively related to Table VIII gunnery proficiency. There is also evidence to suggest that the current Gunnery Qualification Course (Table VIII) does not require the performance of some critical gunnery tasks, especially on the part of the Tank Commander. The Table VIII performance objectives should, therefore, be reviewed to determine if they are indeed valid indicators of combat criterion performance. Tank crew turbulence does not seem to be related to Table VIII performance. However, the job experience of the Gunner was positively related to gunnery proficiency.

TABLE OF CONTENTS

	Page
INTRODUCTION	1
BACKGROUND	1
PROBLEM	1
PURPOSE	3
SCOPE	4
METHOD	4
OVERVIEW	4
APPROACH	7
Research Participants	7
Predictor Variables	7
Criterion Performance Variables	12
Scoring	15
Procedure	16
RESULTS	17
PERFORMANCE ON TRAINING PREDICTORS	17
CRITERION GUNNERY PERFORMANCE	20
TRAINING TASKS AS PREDICTORS OF GUNNERY	22
Regression Analyses of Training Predictors and Criterion Performance	26
RELATIONSHIPS BETWEEN JOB EXPERIENCE AND GUNNERY PERFORMANCE	29
Job Experience Related to Training Task Performance	34
RELATIONSHIP OF ATTITUDES AND TANK GUNNERY PERFORMANCE	36
RELATIVE CONTRIBUTIONS OF SELECTED PREDICTOR VARIABLES TO CRITERION GUNNERY PERFORMANCE	40

Page

DISCUSSION 43

TRAINING TASKS AND GUNNERY PERFORMANCE 43

EXPERIENCE AND GUNNERY PERFORMANCE 46

ATTITUDES AND GUNNERY PERFORMANCE 48

REFERENCES 51

APPENDICES

APPENDIX A 53

APPENDIX B 55

APPENDIX C 57

APPENDIX D 59

APPENDIX E 63

APPENDIX F 69

APPENDIX G 71

APPENDIX H 79

APPENDIX I 80

APPENDIX J 82

APPENDIX K 84

LIST OF TABLES AND FIGURES

		Page
Figure 1.	Schematic Representation of Factors Relating Training and Job Sample Testing	6
Table 1.	Predictor Variables	8
Table 2.	Criterion Performance Variables	14
Table 3.	Group Performance on Training Predictor Tasks	18
Table 4.	Group Criterion Gunnery Performance	21
Table 5.	Correlations of Gunnery Performance Measures Across Gunnery Tables	23
Table 6.	Correlations Between Training Predictors and Criterion Gunnery Performance Measures	24
Table 7.	Correlations of Simulation Performance Measures Across Simulation Engagement Methods	27
Table 8.	Summary of Multiple Regression Analyses for Predicting Gunnery Performance from Selected Training Variables	28
Table 9.	Crew Turbulence by Duty Position for the 9-Week Time Period Prior to Gunnery Qualifications	31
Table 10.	Crew Experience Descriptive Statistics	32
Table 11.	Correlations Between Crew Experience and Criterion Gunnery Performance Measures	33
Table 12.	Correlations Between Crew Experience and Selected Training Predictors	35
Table 13.	Partial Correlations Between 1/60 Scale Cal. 22 Performance Measures and Table VIII Performance Measures	37
Table 14.	Correlations Between Tank Commander and Gunner Attitude Measures and Criterion Gunnery Performance Measures	38
Table 15.	Summary of Significant Multiple Regression Analyses for Predicting Gunnery Performance from Selected Training, Experience, and Attitude Variables	42

INTRODUCTION

BACKGROUND

Over the past three years the Army Research Institute Field Unit in Heidelberg has been engaged in a research and development program aimed at enhancing tank gunnery training readiness in USAREUR armor units. One goal of this effort has been to design and develop a tank gunnery training program which will meet a number of training needs. Specifically the program should: (a) train the critical skills and knowledges necessary to achieve qualification on Tables VIII and IX, crew and platoon tank gunnery qualification courses; (b) provide a systematic training-to-standard approach which leads to skill acquisition and performance sustainment; and (c) be simulation based so that gunnery training can be conducted entirely in garrison or local training areas.

To date, prototype crew and platoon training programs have been designed to these specifications. During 1979 the crew program was tried out and evaluated in a USAREUR armor battalion. The results indicated that the program could be implemented in a garrison environment with only minor modifications required in training objectives and procedures. Because of limitations in time and support it was not possible to perform an adequate experimental evaluation of the program and only limited inferences were made with regard to training program effectiveness. Therefore, the primary question that still remains to be answered is whether the training program is effective in producing tank crews capable of meeting USAREUR qualification standards.

PROBLEM

A common approach used to evaluate military training program effectiveness is to set up an experimental or quasi-experimental test paradigm. On the surface, many of these paradigms contain some or all of the characteristics of valid experimental designs: experimental and control groups are used, pre-tests and post tests are administered, the independent variables are manipulated and quantitative measurements are taken on the dependent variables. The method usually involves training the experimental group on the "new" program while the control group trains "conventionally". Following training, both groups are administered a criterion test and statistics are computed to determine if one group scored significantly better than the other group. The implication of the design is that any differences in criterion scores are produced by the effects of the respective training programs.

If the requirements for a valid experimental design have indeed been met, then the logical inference can be drawn that the variance in the dependent variable is primarily attributable to the effects of the independent variable. However, to the extent that these requirements are not met, little if anything can be concluded about the effects of the independent variables.

Experience has shown that it is seldom possible and extremely difficult to set up the conditions required to run a valid experimental test in a

military field environment. The possible sources of variance, i.e., subject factors, environmental factors, and experimenter factors which must be accounted for are difficult to control in an operational environment (Jeantheau & Andersen, 1966; O'Brien, Crum, Healy, Harris, & Osborn, 1978). In short, an experimental test requires what Campbell and Stanley (1966) call internal validity and if that is not present little can be said about what is actually being tested.

When the conditions for testing the causal relationships between variables cannot be satisfactorily established, an important question can still be answered; namely, to what extent are the variables related? Using the correlational approach, complex variables can be measured in a realistic environment and the degree of relationship between a number of independent and dependent variables can be determined. Applying this approach to training program evaluation, the important question that can be investigated is whether the skills and knowledges which are being trained are related to the criterion performance which is being measured. This has important implications for evaluating both the validity of the training program and the validity and reliability of criterion performance measurement.

A number of studies over the past few years have attempted to establish empirical relationships between various personnel variables, aptitude test scores, and gunnery related skills tests, and performance measures on live fire tank gunnery tests. Eaton and Neff (1978) examined the relationship between on the job experience of various crew members and gunnery performance on Table VIII. They found three kinds of statistically significant relationships: (a) the more time a Tank Commander (TC) and Gunner had trained together, the faster the crew opened fire; (b) the more experience that a TC had in terms of assignment and training as a TC, the more quickly the crew opened fire; and (c) the more months a Gunner was trained as a Gunner, the more targets his tank hit.

In subsequent studies Eaton (1978) and Eaton and Johnson (1979) investigated the use of paper and pencil aptitude tests and gunnery related skills tests (job samples) as possible predictors of tank gunnery performance. While their results showed a number of significant correlations between some aptitude tests and tank gunnery performance measures, these relationships did not hold up with larger subject samples. Using job related skills tests, the authors were able to replicate findings which showed that performance on both a simulated tracking task and a simulated main gun round sensing task was significantly correlated with several measures of live fire gunnery. The results showed that gunners with fewer tracking errors had higher overall gunnery scores, more first round hits, and more moving target hits. Crewmen with fewer sensing errors had higher overall scores on the gunnery test.

In summing up the results of this research, Eaton, Bessemer, and Kristiansen (1979) stated that:

> . . . there appears to be little merit in pursuing research on these paper-and-pencil measures as predictors of Tank Commander or Gunner performance in armor units. Perhaps research efforts could best be directed toward the development and empirical validation of job sample

and simulator techniques based on sound task analyses. Such job sample/simulator research might also lead to measures to supplement prediction of gunnery performance in One Station Unit Training. (p. 54)

Given the past research finding, it seems that a potentially useful approach to training program evaluation is to consider the program as consisting of a number of job sample tasks which should have criterion related or predictive validity. Evaluation then consists of determining the degree to which performance measures of training tasks (job samples) correlate with criterion performance measures. Establishing which training elements or combination of elements relate to criterion performance is necessary for both understanding the relative importance of the training content and also for determining overall training program validity. To date no study has systematically examined the relationship between critical training, personnel, and attitudinal variables and criterion gunnery performance in the same study. The present research investigated these relationships to both validate elements of the Tank Gunnery Training Program and to gain a better understanding of the principal factors involved in tank gunnery training and evaluation.

PURPOSE

The purpose of the research reported here was to investigate the empirical relationships between task performance on critical components of the Integrated Tank Gunnery Training Program Outline for USAREUR Units (Sharon, Kress, & McGuire, 1980) and performance on criterion Tank Gunnery Table VIII. Additional variables relating to crew members' job experience and attitudes were also evaluated as possible predictors of gunnery performance. The specific research objectives were:

1. To determine the relationship between the Tank Commander's and Gunner's performance on critical Tank Gunnery Training Program tasks and performance on criterion Gunnery Table VIII.

2. To determine the relationship between crew members' job experience and criterion performance.

3. To determine the relationship between leadership and organizational climate measures and Table VIII performance.

4. To evaluate the reliability of performance measures for main gun engagements across Gunnery Tables VI, VII, and VIII.

5. To evaluate the relationship bewteen performance on a 1/60 scale subcaliber range versus a 1/20 scale laser simulator range.

Within the framework of these objectives a number of additional issues were also addressed to better understand both the validity and utility of the Gunnery Training Program and the methodological requirements for operational

field tests. Some of these issues concerned: (a) the relationship between particular training tasks, either singly or in combination, and particular types of gunnery performance measures; (b) the determination of which training tasks are related to speed and/or accuracy of performance; and (c) the evaluation of various criterion performance measures to identify those which have the greatest reliability and utility.

SCOPE

The training tasks selected for validation were all drawn from the Integrated Tank Gunnery Training Program Outline for USAREUR Units (Sharon, Kress, & McGuire, 1980). The program was designed for both crew and platoon level gunnery training, but for purposes of the present research, only crew level components were selected for validation. Research was limited to the crew level for two reasons: (a) only one armor battalion was available to support the research and the nine platoons in a battalion comprise too small a sample for statistical evaluation of platoon performance and; (b) criterion performance measures and scoring of platoon exercises require more refinement before they can be used for research purposes to reliably differentiate between specific platoon level training skills and knowledges.

All performance measurement was limited to the Tank Commander's (TC) and Gunner's skills and knowledges as defined by the Training Program tasks and criterion gunnery performance measures. Live fire gunnery tables are tests primarily of the TC's and Gunner's ability to neutralize a variety of targets in different situations. The driver and loader play a relatively constant and minor role during gunnery and their performance is not considered to contribute significantly to the overall variance. Therefore, no performance data was collected specifically on these two crew members. Attitude measures were, however, collected for all members of the crew.

Finally, main gun engagements were the primary criterion performance variables used for evaluation purposes. These engagements are the fundamental basis of tank gunnery proficiency and they also allow more accurate and reliable scoring than do machine gun engagements.

METHOD

OVERVIEW

The main thrust of the research effort was to determine the criterion related validity of elements of the Tank Gunnery Training Program. The basic question of interest was the degree to which performance on the training tasks correlates with performance on the criterion Tank Gunnery Table VIII. If the skills represented in the training tasks are necessary for Table VIII performance then the extent to which these skills are mastered should relate to the scores achieved on the Gunnery Table. If no relationship exists, then an explanation has to be sought as to what the

critical predictors of tank gunnery performance are and how they relate to a training program.

It seems reasonable to assume that the primary predictors of tank gunnery performance are the skills and knowledge acquired during training. Other factors, however, such as attitudes, motivation, and prior experience, may also have a significant impact on criterion performance. Therefore, the scope of the predictor variables in the study were expanded to include attitudinal measures and measures of prior on-the-job experience and crew turbulence.

Figure 1 shows a schematic representation of the relationship between potential performance predictors and job sample testing. The right side of the diagram depicts what has been called by Guion (1979) a Job Content Universe and a Test Content Domain. The Job Content Universe consists of a circumscribed set of skills, knowledges, and behaviors which completely define a given job. The job can be broadly or narrowly defined. Being a tank crewman is a broad definition of a job while acquiring, engaging, and neutralizing enemy targets in combat is a narrower definition. Regardless of how the job is defined, it is seldom feasible or possible to either train or test a person on all elements of the Job Content Universe. Therefore, for training purposes, a job is analyzed to identify its component elements and the most critical of these become the content of a training program. For testing, a sample of job elements is selected and this becomes a Test Content Domain. Ideally performance on the test content domain, or job sample, should predict overall job performance. Similarly, the extent to which the training elements are mastered should predict both job and job sample test performance. This assumes, of course, that both the training elements and the Test Content Domain are valid and that other factors have a somewhat constant influence. In the context of the present research, the Job Content Universe consists of all the ways that a tank crew can neutralize targets in combat, while the Test Content Domain is Table VIII.

The left side of the figure identifies some of the general and specific factors which can determine job and test performance. Individual history refers to the amount and kind of prior job experience and other demographic variables which can influence job performance. Individual competence consists of the general mental and physical aptitudes and abilities that every person brings to a job. These general factors form the background or baseline for the development of specific job related knowledges, decision processes, and physical skills which make up a training program. Within the context of the immediate training or job environment certain attitudes and motivation are also developed which can have a considerable influence on performance.

Either alone or in combination any of the factors mentioned above can have a significant influence on job performance. In terms of training program development and evaluation, it is assumed that the specific training related variables will have the primary influence and will account for a major portion of the performance variance. If this can be demonstrated, then the training program is considered to be valid. To demonstrate this relationship and determine validity, both the evaluation measures and the measurement process have to be reliable.

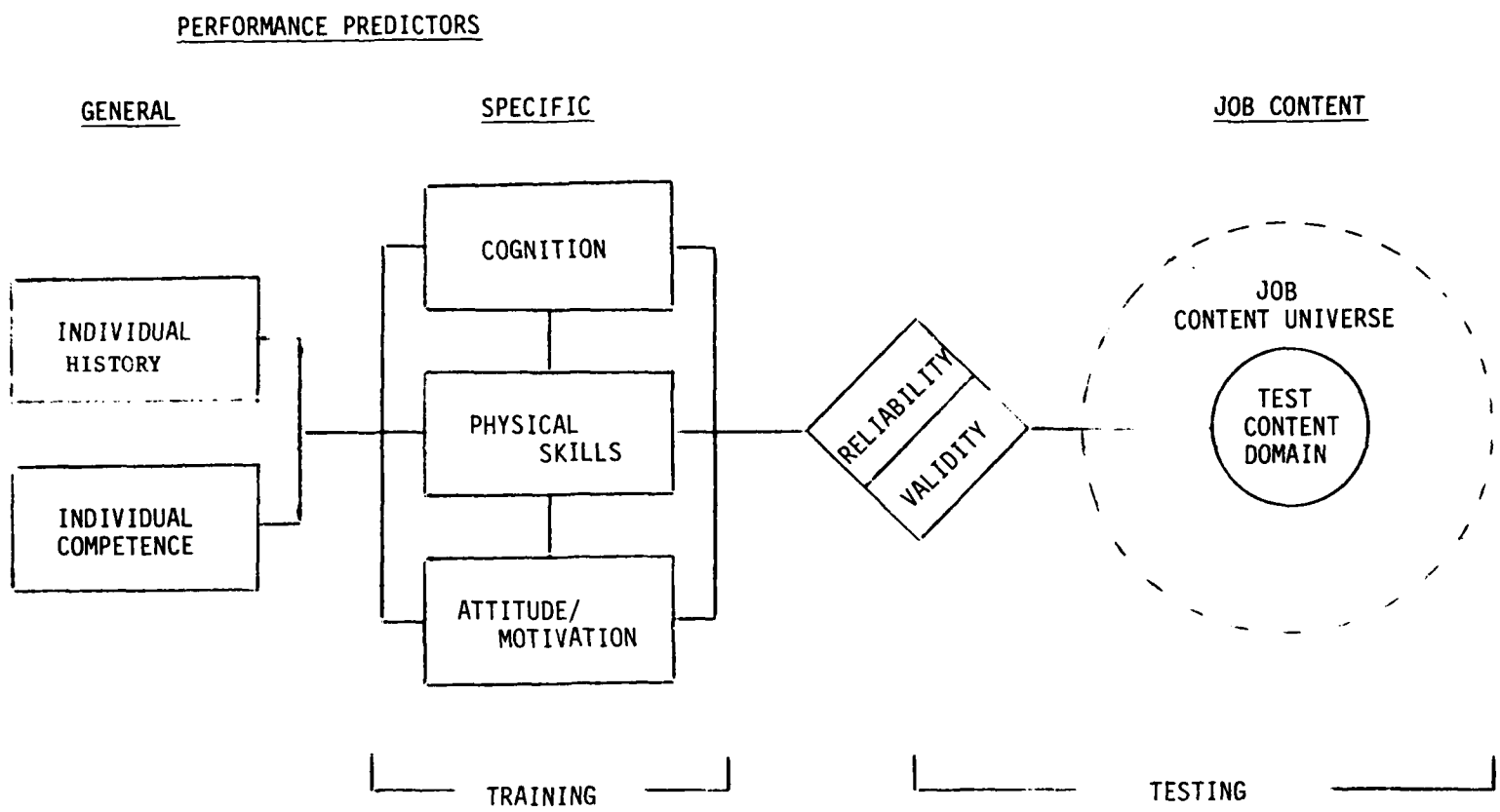

Figure 1: Schematic Representation of Factors Relating Training and Job Sample Testing

In the present research both general and training specific performance predictors were evaluated to determine how they relate to criterion gunnery performance. The general predictors included measures of crew members' prior experience and crew turbulence; the specific predictors included measures of training program task performance and assessments of attitudes relating to leadership and organizational climate. By including variables in addition to those specifically related to the training program, the research was designed to obtain a more comprehensive picture of the variables which affect tank gunnery performance.

APPROACH

Research Participants

The research participants were the tank crew members from one armor battalion in the 3rd Infantry Division, USAREUR. Each of the 54 crews consisted of a Tank Commander (TC), Gunner (GNR), Loader (LDR), and Driver (DR). The research focused primarily on the 54 pairs of TCs and Gunners and, therefore, no performance data was collected on Drivers and Loaders. Attitudinal data was collected on all 216 crew members. Because of the exigencies of collecting data in an operational environment, it was not always possible to collect complete data on all of the predictor and criterion variables. Therefore, wherever data is reported in later sections of the report, the size of the sample will be indicated.

Predictor Variables

The basic research approach consisted of a straightforward correlational design to investigate the relationship between a number of predictor variables and criterion performance measures. Three types of predictor variables were used: (a) training program predictors consisting of measures of critical skills and knowledges identified in the Tank Gunnery Training Program for USAREUR Units; (b) attitudinal predictors based on measures of perceived leadership and organizational climate; and (c) personnel background characteristics which included measures relating to length of job experience and crew turbulence.

Table 1 lists the predictor variables, the crew members tested, and the evaluation measures used. The training program predictors fall into three categories: knowledge, motor skills, and simulated engagements. The knowledge variables tested the Gunner on his knowledge of the main gun reticles and how they are used to take an initial aim and make a fire adjustment in a variety of target situations. The TC was tested on his ability to assess a first round miss and to determine the correct fire adjustment. The motor skills variables focused on the speed and accuracy of the Gunner in aiming and firing at stationary and moving targets. The TC was tested on his ability to use the coincidence range finder to determine the range to a target. The remaining training performance tests consisted of simulated engagements similar to those contained in Table VIII. Each of the training program predictors is described in more detail below.

TABLE 1

PREDICTOR VARIABLES

VARIABLES	CREW MEMBER EVALUATED	MEASURES
TRAINING PROGRAM PREDICTORS		
KNOWLEDGE		
1. Apply sight reticle for initial lay	Gunner	Percent correct
2. Apply sight reticle for fire adjustment	Gunner	Percent correct
3. Determine fire adjustment	TC	Percent correct
PERCEPTUAL/MOTOR SKILLS		
4. Hit stationary targets	Gunner	Percent targets hit Mean time per trial
5. Hit moving targets	Gunner	Percent targets hit Mean time per trial
6. Range to target	TC	Mean ranging error
SIMULATED ENGAGEMENTS		
7. Full Scale + M55 laser	TC and Gunner	Percent hits Percent first round hits Mean opening time Mean total time
8. 1/20 Scale + M55 laser	TC and Gunner	Same as variable 7
9. 1/60 Scale + cal. 22	TC and Gunner	Same as variable 7
ATTITUDINAL PREDICTORS		
1. Perceived leadership a. Initiating structure b. Consideration	TC, Gunner, Loader, Driver	LBDQ-12 leadership questionnaire
2. Organizational climate a. Unit climate b. Supervisory leadership c. Group cohesion d. Mission accomplishment	TC, Gunner, Loader, Driver	General Organizational Questionnaire (GOQ)
PERSONNEL BACKGROUND PREDICTORS		
1. Demographic and experience-related items	TC and Gunner	Questionnaire

Apply Sight Reticle for Initial Lay. This task tested the Gunner's knowledge and ability to use the M32 (periscope) and M105D (telescope) sight reticles under battlesight and precision gunnery conditions. The task was completely simulated by using sight reticles, drawn on clear plastic, and drawings showing a target and a printed fire command. Both the reticles and the targets were drawn to scale to correspond to the situation indicated by the fire command. The fire command specified ALERT, AMMUNITION or BATTLESIGHT, target DESCRIPTION, and DIRECTION. For conditions of an inoperable computer, the command included the RANGE. The Gunner's task was to read the fire command, select the proper reticle, lay the reticle in correct relation to the target to obtain a first round hit and mark it. A total of 22 target situations were tested. These were developed from an engagement matrix based on stationary and moving targets, three types of ammunition (APDS, HEAT, HEP), two types of engagements (precision and battlesight), and two sights (periscope and telescope). Appendix A contains the target condition matrix and a sample exercise.

Apply Sight Reticle for Fire Adjustment. In this task the Gunner was tested on his knowledge and ability to make main gun fire adjustment upon command, and to apply Burst-on-Target (BOT) under a variety of conditions. This task was again simulated using plastic sight reticles and target drawings. Each target drawing was on a separate page which contained all the information required for making fire adjustment; i.e., the initial fire command, first round sensing, and fire adjustment command or indication of where the first round missed the target. The Gunner's task was to select the proper sight reticle and place it on the drawing to obtain a second round hit. The fire adjustment methods tested included BOT, mil change, range change, target form, and standard adjustment. A total of 24 situations were tested. Appendix B contains the test matrix and a sample exercise.

Determine Fire Adjustment (TC). One of the primary responsibilities of the Tank Commander in a target engagement situation is to sense the round, estimate the deviation of the round from the target, and give the Gunner an accurate fire adjustment command. In this simulated task the TC was tested on a series of 20 target drawings. On each drawing a dot near the target indicated the position of a first round miss. Also specified was the fire control instrument used for the first round, the ammunition, and in some cases, an instruction specified that target form was to be used as the adjustment technique. The TC had to determine the appropriate fire adjustment for each case and write out a fire adjustment command. A scaled plastic binocular reticle was available to estimate mil change and meter change fire adjustments. Appendix C contains the conditions matrix and a sample exercise.

For all three of the tests described above, the dependent measure was the percentage correct responses. Scoring was based on an allowable error of plus or minus one mil for battlesight targets and plus or minus one-half mil for precision targets.

Hit Stationary Targets. All Gunners were tested on their ability to aim at and hit stationary targets using their primary sight (periscope). Main

gun fire was simulated with an M55 laser mounted on a Brewster device. The Brewster was coaxially mounted on the main gun tube in accordance with the procedures in FM-17-12-7 (Tank Gunnery Devices). Circular targets were cut out of laser reflective material and scaled to 1/20 scale. An array of 20 targets forming roughly a rectangular pattern were mounted on a wall in front of the tank at a distance which simulated 1100 meters (approximate battlesight gunnery range). All targets were connected by a white tape which indicated the sequence of engagement. The Gunner started with the top left target and engaged each successive target in sequence until all 20 targets had been fired at. The targets were first engaged moving from right to left and were then re-engaged moving from left to right for a total of 40 trials. One shot was allowed per target and a hit was scored if the laser reflected off of any portion of the target. The response measures consisted of the percent targets hit and mean time per trial.

Hit Moving Targets. This task was designed to test the Gunner's perceptual-motor skills in manipulating the hand controls and holding the sight picture on a moving target to achieve a hit. The M55 laser on a Brewster mount simulated main gun firing and 1/20 scale laser reflective cutouts simulated the targets. Flank view tank targets were mounted on a moving belt at a distance which simulated 1200 meters and could be moved both to the left and right at a simulated speed of 25 miles per hour. The Gunner engaged a total of 40 targets, with half moving right to left and the other half moving left to right. The Gunner, using the primary sight, was allowed one shot per target and the response measures were the percent targets hit and the mean time per trial.

Range to Target. In this task the TC was required to determine the range to seven full scale panel targets. The targets depicted frontal tanks and were positioned from 700 to 1900 meters from the tank used for ranging. The coincidence rangefinder was boresighted at 1200 meters and the targets were presented in random order. The TC first visually estimated the range to each target and following this unaided technique, he used the rangefinder to carefully range to each target. While ranging with the rangefinder, he was not allowed to see the range scale. The dependent measures consisted of the mean ranging error for both unaided and rangefinder determinations.

Scaled Range Engagements. Tank Commanders and Gunners were tested in pairs on a variety of engagements using scaled ranges and main gun fire simulators. Two types of ranges and devices were used and all TCs and Gunners performed on both. One set of engagements were fired using 1/60 scale targets and an M16 rifle with a cal. 22 rimfire adapter mounted on the Brewster device. A second range was set up with 1/20 scale targets and these were engaged with an M55 laser mounted on the Brewster device. Descriptions, devices, and procedures for both types of ranges are contained in FM 17-12-7. The target arrays, simulated distances, and types of engagements were identical on both ranges. All targets were engaged using the periscope and were within simulated battlesight range (800-1300) meters. A total of seven engagements including

14 targets were fired on each range: three engagements of one, two, and three stationary targets, respectively; two engagements of one and two moving targets; one engagement of one moving and one stationary target; and one engagement of one moving and two stationary targets. The order in which the ranges were tested was counterbalanced across crews to control for learning effects. The Gunners and TCs were told that they would be presented with a series of tactical engagements and they were to engage and neutralize the targets as quickly as possible. Two shots per target were allowed on all engagements. The engagements were presented randomly and all targets, with the exception of moving targets, were controlled by pop-up devices. Performance measures collected were the total percentage hits, percentage first round hits, mean opening time, and mean total time per engagements.

Full Scale Laser Engagements. These exercises tested TC and Gunner coordination in engaging full scale panel targets under both battlesight and precision gunnery conditions. Frontal tank target panels were placed at actual distances from 700 to 1900 meters. Numbers painted on the targets were used to designate which target(s) to engage in a particular exercise. The Stout Device with M55 laser (FM 17-12-7) was used to simulate main gun fire. A total of 11 engagements involving 17 targets were randomly presented which simulated battlesight and precision engagements, single and multiple targets, and HEAT and APDS ammunitions. Two shots were allowed per target. Total percent hits, percent first round hits, mean opening time, and mean total time were the dependent measures.

The attitudinal predictors consisted of the Leadership Behavior Description Questionnaire 12 (LBDQ) and the General Organizational Questionnaire (GOQ). These questionnaires were administered to all crew members and assessed their attitudes with regard to their leaders, their co-workers, and their unit.

The LBDQ originally came out of the Ohio State studies of the behavior patterns of effective leaders (Hemphill & Coons, 1957). It was very quickly modified for use in military situations (Halpin & Winer, 1957). The scale, now in its 12th revision, is usually given to subordinates who are asked to describe their supervisors' behavior.

As a result of the research over the years, the behaviors rated now fall on two main dimensions called "Consideration" and "Initiating Structure". Consideration items are concerned with the interpersonal attitudes and behaviors of the leader towards the subordinates, e.g., "He is friendly and approachable." Initiating structure items are concerned with attitudes and behaviors towards getting the task done, e.g., "He encourages the following of standard procedures." There is no specific description of the situation in which the behavior occurs and the subordinate presumably rates the leader according to some estimate of its occurrence in various situations. Attempts over the years to correlate the LBDQ scales with various measures of group effectiveness and performance have led to mixed results, which seem to be dependent on the work

situation and the population studied. In general, the research suggests that the "initiating structure" dimension will correlate positively with measures of group effectiveness especially in military settings (Vroom, 1976). The LBDQ was selected as a potential predictor of tank gunnery performance because the tank crew, composed of only four men and under the direction of a Tank Commander, is likely to be more affected by the behaviors and perceptions of the leader than would be the case in a larger organizational setting where the effects of leadership are more dispersed. Appendix D contains a copy of the instrument.

The GOQ is a fairly comprehensive instrument which has been used in a variety of ways by the Army since the mid-1970's to assess organizational climate. The GOQ is based on a series of scales developed by the University of Michigan Institute for Social Research (Taylor & Bowers, 1972). The original Army adaptation of the GOQ contained 21 dimensions of social organization with several indices based on as few as two items. In a recent Army Research Institute project, Sterling and Mietus (1979) performed a data-based factor analysis of the items so that face valid indices based on a sample of two items would be eliminated. Their factored version now contains four major scales--Unit Climate, Supervisory Leadership, Group Cohesion, and Mission Accomplishment. Unit Climate refers to the determinants of individual and group behavior. Determinants include communication flow, decision making practices, etc., which may help or hinder the group in accomplishing its goal. Leadership refers to such behaviors as support, team building, work facilitation, and goal emphasis. Group Cohesion describes whether or not the members work together well or badly and can effectively produce high quality outputs. The readiness, discipline, and cooperation of the group are indicators of mission accomplishment.

The GOQ has been used primarily as a diagnostic tool in the military to evaluate organizational climate and little work has been done to link unit scores with objective measures of group performance. In this study, the scales developed by Sterling and Mietus were correlated with criterion tank gunnery performance measures to assess the validity of the instrument to predict job performance. The GOQ is contained in Appendix E.

The final predictors of tank gunnery performance which were evaluated consisted of measures of tank crew stability and crew member job experience. The specific items of interest were contained in a brief questionnaire shown in Appendix F. Many of these items were adapted from a similar questionnaire used by Eaton and Neff (1978). Items dealing with how long various crew members had served together were verified against company rosters for the three months preceding tank gunnery qualifications.

Criterion Performance Variables

The primary test of tank crew gunnery proficiency is Tank Gunnery Table VIII (Crew Combat Course). Table VIII consists of a series of tactical target engagements which require the crews to acquire, engage, and hit single or

multiple targets using the main gun and/or machine guns. Scoring is accomplished in terms of the speed and accuracy with which targets are engaged. An accuracy and time standard is specified for each engagement and this serves as the qualification criterion. The Table consists of a day portion (Table VIII A) and a night portion (Table VIII B). During the day portion the tank has to move along a course road between engagements. At night, because of safety requirements, there is very limited manuever and all engagements are fired from two adjacent firing points.

Table VIII is the culmination of crew gunnery. Prior to firing Table VIII, all crews fire preparatory Gunnery Tables VI and VII. All three Gunnery Tables are very similar in terms of the kind of target engagement situations presented. The differences among the tables are that on Table VI the firing tank is always stationary and the table is used primarily to acclimate the crews to live fire and to confirm the boresight and zero. Some commanders do use the table to build the crews' confidence in live fire gunnery. On Table VII the firing tank moves and fires the same engagements as on Table VIII only in a different sequence and on different terrain. Appendix G contains the battalion score sheets for the three tables which list the task, conditions, and standards for each engagement. For research purposes separate score sheets were developed to facilitate the recording of Hit-Miss and time scores on each table. Not shown on the Table VIII score sheet is a moving target main gun engagement (two rounds TPT) which was added for research purposes to increase the number of moving target engagements. Tank Commanders were instructed to fire both rounds at the target even if they scored a hit with the first round.

Performance data was collected for each crew on all three gunnery tables. Because of the limited number of research personnel and equipment, it was felt that reliable night firing scores could not be collected on Tables VI and VII. Therefore, the performance data from those two tables reflect only day main gun engagements. Table VI (Day) involved two moving tank targets and ten stationary tank targets. Table VII (Day) involved one moving tank and seven stationary tank targets. Performance data on Table VIII included both day and night engagements for a total of four moving targets and ten stationary targets. Table 2 lists the criterion performance variables and the measures associated with each one. Table VIII performance was of primary interest in terms of the relationship between the predictor variables and criterion performance. Table VI and VII measures were used to evaluate the reliability of scores among the three tables. All measures were based on main gun Hit-Miss scores and elapsed time and are defined as follows:

$$\text{Percent hits} = \frac{\text{number of targets hit}}{\text{number of rounds fired}} \times 100$$

$$\text{Percent first round hits} = \frac{\text{number of targets hit with first round}}{\text{number of targets engaged}} \times 100$$

$$\text{Percent targets hit} = \frac{\text{total number of targets hit}}{\text{number of targets engaged}} \times 100$$

$$\text{Percent successful engagements} = \frac{\text{number of engagements in which all targets were hit}}{\text{number of engagements completed}}$$

$$\text{Mean opening time} = \frac{\text{sum (across engagements) of elapsed time from target appearance to first round}}{\text{number of engagements}}$$

$$\text{Mean total time} = \frac{\text{sum (across engagements) of elapsed time from target appearance to last round}}{\text{number of engagements}}$$

It can be assumed that both the accuracy and speed measures will tend to be highly intercorrelated; however, each measure emphasizes a different aspect of performance which, depending on the situation, can have critical tactical significance. Percent hits measures overall accuracy in terms of the number of rounds fired and, therefore, is an indicator of ammunition conservation. Percent first round hits and mean opening time are indicators of the ability to shoot first and score a hit with the initial round. Percent targets hit is an indicator of the ability to hit all types of main gun targets on the table and mean total time measures the average time required to engage an array of targets in an engagement. Finally, percent successful engagements measures the ability to hit all targets (both main gun and machine gun) in an engagement. By correlating the predictor variables with each of the measures, the goal was to determine which measure(s) was the most sensitive in terms of criterion related validity and reliability.

Scoring. All scoring and data recording was accomplished by members of the research team. It was originally hoped that the same people would score all three gunnery tables. This turned out to be impossible since the gunnery schedule required that some of the tables be run concurrently. Therefore, a data collection team was assigned to each of the tables so that one team scored all of Table VI, another team scored all of Table VIII, and the scoring of Table VII was divided between two teams.

The stationary tank targets consisted of either Partial Defilade wood panels (200 cm x 140 cm) or Full Frontal wood panels (300 cm x 225 cm). The moving targets were Full Flank wood panels (600 cm x 225 cm) mounted on a carriage which moved on rails. With the exception of two targets on Table VI, all stationary tank targets were mounted on SAAB pop-up devices. The SAAB device provides the capability to raise and lower targets using a RF transmitter. Sensors attached to the target are activated when a round passes through the panel resulting in the target being lowered automatically when a hit is achieved. Because of an insufficient number of SAAB devices,

TABLE 2

CRITERION PERFORMANCE VARIABLES

VARIABLES	MEASURES
TABLE VIII	
1. Main Gun Accuracy	a. Percent hits b. Percent first round hits c. Percent targets hit d. Percent successful engagements
2. Main Gun Speed	a. Mean opening time b. Mean total time
3. Stationary Target Accuracy	a. Percent hits b. Percent first round hits c. Percent targets hit
4. Moving Target Accuracy	a. Percent hits b. Percent first round hits c. Percent targets hit
TABLES VI and VII (Day Only)	
5. Main Gun Accuracy	a. Percent hits b. Percent first round hits c. Percent targets hit

two main gun target panels on Table VI were mounted on a target frame which did not drop when hit.

Scoring was accomplished using 7 x 50 binoculars to sense the results of each round fired. On Table VI scorers were positioned in the control tower with two people dividing the targets and sensing and one person recording the results. On Tables VII and VIII, one scorer and one data recorder rode in the control jeep which followed the firing tank. On Table VIII moving targets were both sensed and physically scored for hits after the firing tank passed the position (all holes were patched on physically scored targets).

Time data were collected using stop watches. Although times were collected on both Tables VI and VII, these data were not used in the analysis because it was felt that they lacked sufficient reliability. Both of these tables are considered training and, therefore, the conditions required for reliable timing of each engagement were not always met. Table VIII, the qualification course, was run in a very standardized fashion which allowed reliable time scoring. On each engagement two stop watches were started simultaneously when a target first appeared. The first watch was stopped at the sound of the first round (opening time) and the second watch was stopped either when all the targets had been hit or time was called by the controller (total time).

Procedure

The research was conducted in two phases. In the first phase data were collected on the predictor variables at home station in the week prior to the battalion moving to Grafenwoehr training area. In the second phase criterion performance data were collected at Grafenwoehr during the battalion's scheduled gunnery period.

At the time that the tests on the training program predictors were administered, the battalion had just completed its normal training cycle in preparation for gunnery qualifications. To maximize variance no training was conducted using the specific tasks and methods contained in the prototype program. Paper and pencil tests and questionnaires were administered on a group basis by research personnel. Tests on motor skills and simulated engagements were set up as individual stations and Gunners or TC-Gunner pairs rotated through the stations. Again research personnel provided the scoring and data collection. One company per day was tested and an additional day was used for make-up tests.

At Grafenwoehr all crews fired Tables VI, VII, and VIII in that order. Performance data were collected by research personnel using the scoring procedures described previously. On Table VIII cassette tape recorders were tied into the communication system on several tanks to record the intra-crew communications while they conducted the combat course. The tape recordings were used to gain information on the degree to which formal target engagement procedures were used by the Gunner and Tank Commander, i.e., target acquisition, fire commands, subsequent fire adjustment commands.

RESULTS

As is often the case in field research, collecting complete data on all subjects is not possible. The present study was no exception. All data were collected in a relatively short time span and, especially in the case of the live fire gunnery tables, there was no opportunity to go back and re-administer performance tests or questionnaire instruments. Data were missed for a number of reasons including subject unavailability, crew member re-assignment, equipment malfunctions, weather, time constraints, and the decision of the data collector that a particular bit of data was not completely reliable. For purposes of statistical analysis, it was assumed that missing data occurred randomly with respect to their effect on the variables being measured.

Performance data consisted of accuracy and time scores. For data analysis purposes mean time scores were used while raw scores for accuracy were converted to percentage measures. In all data analytic procedures, the maximum number of cases appropriate for each variable was computed. This often resulted in unequal Ns across variables and data analytic procedures. For example, data were collected from 50 of 54 Gunners on the training predictor task "apply sight reticle for initial lay." Complete criterion performance data (Table VIII) were collected on 53 of 54 tank crews. Therefore, where overall group performance data are reported, 50 cases were included for the predictor task "initial lay" and 53 cases were included for Table VIII performance. When "initial lay" was correlated with criterion performance, however, only 45 cases were used. This was necessary because four Gunners and four Tank Commanders (not necessarily on the same tank) were no longer in these positions on the criterion tests. Thus, in correlating predictor with criterion variables, all cases had to be dropped which involved either the changed Gunners, Tank Commanders, or both. In the above example, of the 50 Gunner predictor scores which could have been correlated, four were dropped because the Gunners had changed and one was dropped because criterion performance measures were not collected on that tank.

When multiple regression analyses were used, all cases were dropped which did not have complete data for all variables. This resulted in an equal number of cases for all variables in the regression; however, the total number of cases was also reduced.

PERFORMANCE ON TRAINING PREDICTORS

The training proficiency of TCs and Gunners relative to the training tasks is indicated by the average group performance on each of the training predictors. Table 3 shows the mean scores for each of the performance measures on all of the training tasks. The first two paper and pencil tasks in Table 3 involved the Gunner and tested his knowledge of how to take a

TABLE 3

GROUP PERFORMANCE ON TRAINING PREDICTOR TASKS

TRAINING TASKS	N	MEAN	S.D.
Paper and Pencil			
Percent correct initial lay (GNR)	50	41	22.0
Percent correct fire adjustment (GNR)	47	40	19.7
Percent correct fire adjustment (TC)	54	29	13.3
Stationary Targets			
Percent targets hit	50	85	11.1
Time per trial (seconds)	50	3.7	1.2
Moving Targets			
Percent targets hit	46	86	15.6
Time per trial (seconds)	46	4.6	1.8
Ranging			
Ranging error in meters (Rangefinder)	32	86	70.4
Ranging error in meters (unaided)	39	264	146.3
Full Scale Engagements			
Percent hits	41	87	12.1
Percent first round hits	41	84	15.3
Opening time[1] (seconds)	41	13.3	3.3
Total time (seconds)	41	22.8	5.2
1/60 Scale Engagements			
Percent hits	44	49	19.4
Percent first round hits	44	52	20.8
Opening time (seconds)	44	8.9	2.6
Total time (seconds)	44	24.7	7.2
1/20 Scale Engagements			
Percent hits	41	78	14.5
Percent first round hits	41	75	17.8
Opening time (seconds)	41	7.4	1.2
Total time (seconds)	41	15.5	2.9

[1]All opening and total times are per engagement

correct initial sight picture for a first round hit and how to lay the reticle correctly during fire adjustment for a second round hit. The third paper and pencil task tested the TC on his ability to determine the correct fire adjustment following a first round miss.

The results show that Gunners on the average performed less than 50 percent of their exercises correctly (41 percent on initial lay and 40 percent on fire adjustment). Tank Commanders were able to determine the correct fire adjustment on the average for only 29 percent of their problems. The exercises in each of the paper and pencil tasks were broken out by type of target engagement conditions and performance measures were computed for each condition. Appendix H contains these results. Engagement conditions were not independent; therefore, the percent correct summed over conditions will not equal 100 percent. The data in Appendix H indicates that in applying the sight reticle for initial lay, Gunners performed best on periscope engagements (54 percent correct) and stationary target engagements (52 percent correct) and worst on telescope engagements (27 percent correct) and moving target engagements (30 percent correct). On fire adjustment, Gunners again did best on periscope exercises (50 percent correct) and on the Burst-on-target (BOT) fire adjustment technique (51 percent correct). Poorest fire adjustment performance was again with telescope exercises (30 percent correct). Tank Commanders demonstrated the best knowledge of target form fire adjustment (52 percent correct) and had the most difficulty with fire adjustments involving mil change standard adjustments (11 percent correct) and range change adjustments (12 percent correct).

Returning to Table 3, the perceptual-motor performance of Gunners in being able to hit individual stationary and moving targets was similar and relatively high. On the average, Gunners hit 85 percent of both stationary and moving targets; however, the average time for engaging a moving target was slightly longer than for stationary targets. The performance of Tank Commanders in ranging to a target showed, as would be expected, that they were more accurate in ranging using the rangefinder than without. The average errors of 86 meters for the rangefinder and 264 meters for unaided methods compares favorably to the performance standards in the Soldiers' Manuals ($\pm$ 3 percent error with rangefinder and $\pm$ 20 percent error using unaided techniques) given that the median range to target was approximately 1400 meters.

On the two simulation engagement tasks using the M55 laser simulator (Full Scale and 1/20 scale engagements), Gunner and TC pairs achieved a relatively high percent of overall hits and first round hits. The high degree of accuracy on the Full Scale Engagements could be due to the fact that no moving targets were included on these engagements. Target hit performance using the 1/60 scale cal. 22 range was lower than for the other two methods with percent hits and percent first round hits averaging approximately 50 percent.

One of the objectives of the research was to compare the subcaliber 1/60 scale range with the 1/20 scale laser range both in terms of training

performance and their individual relationship to criterion performance. For this purpose the engagement exercises tested with these two simulation methods were identical and administered in a counterbalanced manner to cancel learning effects. Statistical tests were first computed on each of the performance measures for both 1/60 scale engagements and 1/20 scale engagements to insure that the counterbalancing had been effective. The results showed that there were no statiscally significant differences in the performance measures as a result of the testing sequence: for 1/60 scale performance measures t varied between .29 and 1.69, df=39, $p>.05$; for 1/20 scale performance measures t varied between .25 and 1.26, df=42, $p>.05$. Statistical tests were next computed to directly compare performance on the 1/60 scale cal. 22 range with the 1/20 scale laser range. The results of the tests showed that a significantly greater percent hits ($t=8.01$, df=36, $p<.001$) and percent first round hits ($t=6.22$, df=36, $p<.001$) were achieved on the laser range as opposed to the cal. 22 range. Opening times and total times were also significantly faster on the 1/20 scale laser range, ($t=3.94$, df=36, $p<.001$ and $t=9.64$, df=36, $p<.001$ respectively).

No statistical comparisons were computed for the Full Scale Engagements since the simulated engagements conducted with this method differed from the other two simulation methods.

CRITERION GUNNERY PERFORMANCE

The day and night portions of live fire Gunnery Table VIII constitute the criterion for tank crew gunnery performance. As a whole the test battalion performed very well with 44 of 54 tanks (81 percent) meeting the qualification standards for Table VIII (Appendix G contains the standards). Table 4 summarizes mean group performance on all three gunnery tables in terms of speed and accuracy measures. The data for Table VIII are based on both day and night performance while only day performance is included for Tables VI and VII. Overall main gun accuracy scores are shown for all three tables. For Table VIII main gun speed measures are included and overall main gun performance is also broken out in terms of stationary and moving target accuracy. The final performance measure for Table VIII, Total Percent Successful Engagements, shows the percent of engagements in which all targets, both main gun and machine gun, were hit.

A comparison of gunnery accuracy measures across Table VI, VII, and VIII shows that mean performance is very similar for all three tables with accuracy on Table VII being somewhat higher. Overall main gun accuracy, especially in the case of Table VIII, could be characterized as follows: approximately two rounds were required to achieve a target hit, there was a 50 percent chance of a first round hit, approximately 75 percent of the main gun targets were hit, and on Table VIII all the targets were hit on 50 percent of the engagements. The average time to open fire with the main gun was approximatel seven seconds and the average total time for an engagement was 35 seconds. The reader should keep in mind that the maximum time standard for a Table VIII

TABLE 4

GROUP CRITERION GUNNERY PERFORMANCE

GUNNERY PERFORMANCE	MEAN	S.D.
TABLE VIII (DAY + NIGHT) N=53		
Main Gun Accuracy		
Percent hits	56	13.6
Percent first round hits	51	14.7
Percent targets hit	73	15.0
Main Gun Speed		
Opening time[1] (seconds)	6.9	2.4
Total time (seconds)	34.5	5.2
Stationary Target Accuracy		
Percent hits	59	16.8
Percent first round hits	58	18.1
Percent targets hit	79	18.9
Moving Target Accuracy		
Percent hits	52	26.1
Percent first round hits	34	30.7
Percent targets hit	59	25.5
Total Percent Successful Engagements	49	15.8
TABLE VI (DAY ONLY) N=54		
Main Gun Accuracy		
Percent hits	57	14.6
Percent first round hits	57	19.6
Percent targets hit	82	11.7
TABLE VII (DAY ONLY) N=52		
Main Gun Accuracy		
Percent hits	64	20.6
Percent first round hits	62	22.8
Percent targets hit	84	17.8

[1]All opening and total times are per engagement

engagement is 40 seconds and that the control officer normally stopped engagements which exceeded that time limit. The accuracy measures for moving versus stationary targets indicate, not surprisingly, that accuracy scores are higher for the latter. Since only four moving targets were used on Table VIII, all subsequent analyses in this report which deal with Table VIII measures will use only the overall main gun accuracy scores which include both stationary and moving targets.

One question of interest in this study was to determine the degree of relationship in the gunnery performance measures across the three gunnery tables. Accordingly, Pearson product-moment zero order correlation coefficients were computed between corresponding performance measures on all three tables. Appendix I contains the complete intercorrelation matrix and Table 5 shows the correlation of each accuracy measure across the gunnery tables. To make the measures comparable, only day scores on Table VIII were correlated. The percent of machinegun targets hit on all three tables was also included in the correlation analysis. None of the correlations were found to differ significantly from zero indicating that performance on the practice gunnery tables (VI and VII) did not predict performance on Table VIII nor were the measures related across the tables. This lack of relationship between measures on the different tables is probably due to a number of factors. The three gunnery tables are run on different ranges, for different purposes (training versus qualification), using different target arrays, and in the case of Tables VI and VII, the administration of the tables is not as strictly controlled as on Table VIII. Finally, by correlating only day engagements, the number of engagements was reduced which could restrict the range of scores and thus affect the correlation coefficient.

The remainder of this report will examine the relationship between various predictor variables and criterion gunnery performance. Criterion gunnery performance will consist of the overall main gun accuracy and time measures for day and night Table VIII engagements.

TRAINING TASKS AS PREDICTORS OF GUNNERY PERFORMANCE

The primary objective of the research was to investigate the relationship between performance on critical training tasks and criterion gunnery performance. Zero order correlation coefficients were computed between each of the training task performance measures and the Table VIII performance measures. Table 6 presents the results. A total of 53 complete cases were available for Table VIII measures; however, as mentioned previously, all these cases could not be correlated because of TC or Gunner turbulence on the criterion test. The number of cases correlated for each variable is shown in parentheses in the table.

The results show first, that there were no significant correlations for either Gunner or TC between the paper and pencil performance tests (initial lay and fire adjustment) and criterion gunnery performance. The percent of

TABLE 5

CORRELATIONS OF GUNNERY PERFORMANCE

MEASURES ACROSS GUNNERY TABLES

Gunnery Performance Measure	GUNNERY TABLES		
	VI vs. VII	VI vs. VIII[1]	VII vs. VIII[1]
% Hits	-.01	.07	.19
% FR Hits	.02	.07	.23
% Targets Hit	-.11	-.11	.18
% Machinegun Hits	-.11	-.16	-.25
	No correlations in the table are significant ($p > .05$, two tailed)		

$46 \leq N \leq 54$

[1]For comparisons among the gunnery tables only the day scores for Table VIII were correlated with the day scores of the other tables.

TABLE 6

CORRELATIONS BETWEEN TRAINING PREDICTORS

AND CRITERION GUNNERY PERFORMANCE MEASURES

TABLE VIII

TRAINING TASKS (N=)	% Hits	% FR Hits	% Targets Hit	% Successful Engagements	Opening[1] Time	Total[1] Time
Initial Lay (45)	.03	-.11	.02	.06	-.05	.29
Fire Adj. (GNR) (43)	.17	-.01	.12	-.03	-.24	-.02
Fire Adj. (TC) (49)	.11	.09	.15	.12	.16	.00
Stat. Target Hit (45)	-.05	-.17	-.06	-.14	.16	.33*
Stat. Target Time[1] (45)[1]	.02	.17	-.08	-.02	.33*	.24
Moving Targets Hit (44)	.32*	.17	.38**	.32*	-.14	-.04
Moving Target Time[1] (44)[1]	.11	.03	.01	.22	.23	.03
Ranging (Aided) (28)	.27	.34	.19	.33	-.12	-.29
Ranging (Unaided) (34)	-.13	-.07	-.18	-.16	.20	.16
Full Scale (35)						
% Hits	.13	.15	.03	-.07	.21	.20
% FR Hits	.15	.14	.09	-.04	.05	.13
Opening Time[1]	-.29	-.39*	-.30	-.31	.28	.38*
Total Time[1]	-.20	-.35*	-.21	-.14	.22	.28
1/60 Scale (36)						
% Hits	.27	.28	.17	.36*	.15	-.23
% FR Hits	.32	.33*	.15	.35*	.22	-.15
Opening Time[1]	-.27	-.29	-.42**	-.29	.38*	.31
Total Time[1]	-.26	-.32	-.35*	-.31	.19	.34*
1/20 Scale (35)						
% Hits	.24	.25	.37*	.15	-.25	.06
% FR Hits	-.02	.03	.17	.09	-.28	-.01
Opening Time[1]	.06	.07	-.13	-.13	.45**	.25
Total Time[1]	-.14	-.07	-.45**	-.25	.64**	.17

[1]The relationship between speed and accuracy measures is such that a negative correlation indicates better performance, i.e., time to perform decreases while accuracy increases.

*$p < .05$ two tailed

**$p < .01$ two tailed

stationary targets hit on the training task correlated significantly and positively with total Table VIII time indicating that the greater the percent of targets hit on the training task the longer time it took to complete a criterion test engagement. Average engagement time on stationary targets correlated significantly with Table VIII opening time indicating that the more time spent on a stationary target engagement the longer the time to open fire on Table VIII. A very strong relationship was found between the percent of moving targets hit in training and Table VIII performance with significant correlations on percent hits, percent targets hit, and percent successful engagements. No significant correlations were found for any of the ranging tasks.

Looking at the simulation engagement training methods, a number of accuracy and speed measures for both the 1/60 scale cal. 22 and 1/20 scale laser methods correlated significantly with the criterion measures. Percent hits on 1/60 scale was significantly related to Table VIII percent successful engagements. Percent first round hits on 1/60 scale correlated significantly with both percent first round hits and percent successful engagements on the criterion. There were also significant correlations between 1/60 scale opening and total times and the corresponding measures respectively on Table VIII. Significant negative correlations were found between 1/60 scale opening and total times and Table VIII percent targets hit showing that as time on the 1/60 scale decreases, percent targets hit on Table VIII increases.

For the 1/20 scale laser method, significant correlations were found between percent laser hits and percent Table VIII targets hit; laser opening and total times correlated significantly with Table VIII opening time; and laser total time correlated significantly and negatively with percent targets hit on the criterion.

On the Full Scale Engagements, there were significant and negative relationships between opening and total times and Table VIII percent targets hit. Full Scale opening time also correlated significantly with Table VIII total time.

Of additional interest are the inter-relationships among the training variables, particularly the three simulation engagement methods. Appendix J contains the complete intercorrelation matrix for all of the variables. In examining the matrix, the reader should keep in mind that some correlations are not meaningful, such as the TC ranging and fire adjustment tasks, when correlated with some of the Gunner's tasks since these variables would be inherently unrelated. As might be expected, the matrix shows a number of significant intercorrelations among the training tasks. Gunner initial lay is significantly related to Gunner fire adjustment, percent stationary targets hit, and cal. 22 percent first round hits. Percent stationary targets hit correlates significantly with some performance measures on both the Full Scale laser and on cal. 22 engagements. Percent moving targets hit correlates significantly with cal. 22 opening time and 1/20 scale laser percent hits.

The relationships between the performance measures on the three simulation engagement methods were broken out separately and are shown in Table 7. No significant relationships were found between accuracy measures across any of the simulation methods. Opening time and total time, however, were both significantly related between the 1/60 scale and 1/20 scale methods. Opening time only correlated significantly between the Full Scale and the 1/60 scale method.

Regression Analyses of Training Predictors and Criterion Performance

The zero order correlations described above show the individual relationships between various training task measures and criterion performance measures. Also of interest is the predictive potential of several of the variables combined in a multiple regression analysis. Because of the relatively small sample size it was not reasonable to enter all of the variables shown in Table 7 into a multiple correlation. Therefore, certain task variables had to be eliminated. All of the measures on the Full Scale Engagements were eliminated because of their relatively limited significant correlations with the criterion and with the other two simulation engagement methods. Both the 1/60 scale cal. 22 measures and the 1/20 scale laser measures were retained to test directly their relative predictive potential. The Gunner initial lay variable was retained as a representative knowledge task and both Gunner and TC fire adjustment tasks were eliminated. *Percent stationary and moving targets hit* measures were also retained but the times associated with these variables were eliminated. Finally, the two ranging tasks were eliminated because of their lack of correlation with the criterion.

Two separate sets of multiple regression analyses were computed. In one set the independent variables were Gunner initial lay, stationary targets hit, moving targets hit, and all of the 1/20 scale measures. The other set was similar except that the 1/60 scale measures were substituted for the laser measures. In each set of regressions separate regression analyses were computed for the independent variables and each of the Table VIII measures. Standard forward stepwise multiple regression techniques were used. In all analyses F was set at 2.89, $p<.10$ as the selection criterion for entry of an independent variable into the analyses. Only cases which had complete data on all of the variables were used, thus the Ns in each set of regressions were equal.

Table 8 summarizes the results of both sets of regression analyses. The table includes only those regressions which resulted in statistically significant ($p<.05$, two tailed test) correlations with the criterion measures. In the first set of analyses using the 1/20 scale laser measures, significant correlations were obtained with only two of the six Table VIII criterion performance measures. Total time on the laser engagements correlated significantly with Table VIII percent targets hit (total time on training tasks decreased as target hits on criterion increased), however, none of the other training variables met the entry criterion ($p<.10$) for inclusion in the

TABLE 7

CORRELATIONS OF SIMULATION PERFORMANCE

MEASURES ACROSS SIMULATION ENGAGEMENT METHODS

Simulation Performance Measure	SIMULATION METHODS		
	Full Scale vs. 1/20 N=27	Full Scale vs. 1/60 N=30	1/60 vs. 1/20 N=32
% Hits	.05	.18	-.07
% FR Hits	-.01	.09	-.22
Opening Time	.32	.48*	.60**
Total Time	.29	.26	.48*

*$p < .01$ two tailed
**$p < .001$ two tailed

TABLE 8
SUMMARY OF MULTIPLE REGRESSION ANALYSES FOR PREDICTING
GUNNERY PERFORMANCE FROM SELECTED TRAINING VARIABLES

I.
Significant Regressions on Initial Lay, Stationary Targets Hit,
Moving Targets Hit, and 1/20 Scale Engagement Measures. N=31

Table VIII Dependent Variable	Variable Entered[1]	B	Individual F	Multiple R	R^2	R^2 Change	Simple R	Overall F
% Targets Hit	1/20 Scale Total Time	-2.395	9.04	.487	.237	.237	-.487	9.04**
Opening Time	1/20 Scale Total Time	.696	28.16	.696	.484	.484	.696	
	1/20 Scale % Hits	.042	2.91	.730	.533	.048	-.252	15.99**

II.
Significant Regressions on Initial Lay, Stationary Targets Hit,
Moving Targets Hit, and 1/60 Scale Engagement Measures. N=32

Table VIII Dependent Variable	Variable Entered[1]	B	Individual F	Multiple R	R^2	R^2 Change	Simple R	Overall F
% Hits	1/60 Scale Opening Time	-2.693	7.38	.296	.087	.087	-.296	
	1/60 Scale % FR Hits	.204	3.48	.443	.196	.108	.279	
	Stationary Tgts. Hit	.418	3.30	.530	.281	.084	.161	3.65*
% FR Hits	1/60 Scale Opening Time	-2.233	5.63	.339	.115	.115	-.339	
	1/60 Scale % FR Hits	.231	4.13	.475	.225	.110	.274	4.22*
% Targets Hit	1/60 Scale Opening Time	-3.660	15.00	.486	.236	.236	-.486	
	Stationary Tgts. Hit	.483	4.84	.588	.345	.109	.085	7.66**
Opening Time	1/60 Scale Opening Time	.448	10.59	.510	.260	.260	.510	10.59**
Total Time	1/60 Scale Total Time	.305	5.54	.349	.122	.122	.349	
	Initial Lay	.072	3.54	.466	.217	.095	.261	4.04*

[1]Criterion for Entry F=2.89, $p < .10$
*$p < .05$
**$p < .01$

regression. When the dependent variable was Table VIII opening time, two training measures were selected, both from the 1/20 scale laser measures: total time and percent hits (multiple R=.73, $p<.01$).

The second set of regressions which included the 1/60 scale cal. 22 measures resulted in significant correlations with five of the six criterion measures. In each of the five cases at least one of the cal. 22 measures was selected into the regression. Table 8(II) identifies all of the training variables which met the selection criterion for each of the criterion performance measures and gives the multiple R's and significance levels. The only dependent variable for which there were no significant correlations was percent successful engagements. Overall, the results in the table show that the 1/60 scale cal. 22 measures, either alone or in combination, are the strongest predictors of criterion performance, although the percent of stationary targets hit and the Gunner's knowledge of initial lay add significantly to the amount of explained variance on some of the performance measures.

RELATIONSHIPS BETWEEN JOB EXPERIENCE AND GUNNERY PERFORMANCE

Crew member job experience and crew turbulence were the second set of variables investigated in this study in terms of their relationship to criterion gunnery performance. Gunnery Table VIII tests the Gunner and Tank Commander on their abilities to perform their individual jobs and also tests the crew as a whole on their ability to work together. It is reasonable to expect then that both the length of time that a Gunner and TC have worked in their respective duty positions, and the length of time that they have worked together and with other members of the crew will relate to overall gunnery performance.

Gunner and TC job experience and crew turbulence were assessed using a questionnaire (Appendix F) and company crew rosters. The questionnaire asked how long the Gunner and TC had been assigned together, how long all members of the crew had served together, the amount of time the Gunner and TC had worked in their duty positions respectively, and the number of times each had fired the various live fire gunnery tables. The crew rosters were used to tabulate the amount of crew turbulence which occurred in the battalion in the nine weeks prior to Table VIII qualification.

In computing crew turbulence, two types of turbulence were defined: (a) Duty Position Turbulence, which refers to a personnel change at a duty position within a particular tank crew. For example, turbulence at the Gunner's position means that the person at the Gunner's position at one point in time is no longer in that position at the second point in time. (b) Crew Personnel Turbulence refers to Duty Position Turbulence which is caused when new personnel join a crew. For example, the Tank Commander leaves a crew, his position is filled by the Gunner, and a new man joins the crew to fill the Gunner's position. This would result in two cases of

duty position turbulence and one case of crew personnel turbulence (two duty positions are affected but only one new man has joined the crew). As a rule, duty position turbulence is greater than crew personnel turbulence since crew members change positions within a crew more often than they change crews.

Crew turbulence was computed by comparing the crew rosters from nine weeks prior to gunnery with the crew rosters on Table VIII. Each crew position was examined to determine if the person holding the position had changed and if new personnel had entered the crew. Table 9 summarizes the amount of turbulence at each duty position for the entire battalion of 54 tanks. Of the 216 duty positions, 109 (50 percent) experienced a personnel change over the nine week period. Of the 216 original crew members, 81 (38 percent) were no longer with their crews after nine weeks. Out of a total of 54 tanks, 47 (87 percent) experienced at least one instance of turbulence in this time frame. The loader position had the most turbulence in terms of both duty and crew turbulence. The TC position had the least duty position turbulence while the TC and driver positions experienced the least crew personnel turbulence.

The results of the questionnaire data are summarized in Table 10. The two items dealing with individual crew turbulence show that on the average (median) 50 percent of the tank crews had been together 1.2 months or less. The same median measure also showed that 50 percent of the TC-Gunner pairs had been together less than 2 months. The job experience measures show that, on the average, Tank Commanders had served longer as TCs in their company, as TCs on M60 tanks, and on any position in M60 tanks as compared to the Gunner. Tank Commanders also had more experience on live fire gunnery tables over the last two years than Gunners.

The measures summarized in Table 10 served as the basis for computing correlation coefficients between crew experience and criterion gunnery performance. Rather than using the raw experience scores in the correlation analysis, natural log transformations were directly computed for each of the experience measures. This was done for two reasons: (a) the functional relationship between experience and performance is probably not linear but rather closer to a logarithmic function in the sense that performance gains during early experience are relatively greater than performance gains later on, and (b) since the experience measures were all positively skewed, a log transformation served to reduce the degree of skewness considerably.

Table 11 shows the correlations between the transformed experience scores and the criterion gunnery measures. No statistically significant relationships were found between the length of time the crew had served together, or the time that the TC and Gunner had been assigned together, and performance on any of the speed or accuracy measures. There were also no significant correlations between any of the Tank Commander experience measures and gunnery performance. Gunner experience, however, was related to Table VIII performance. The length of time the Gunner had been a Gunner in the company, a Gunner on M60 tanks, and the overall number of live fire gunnery tables he fired in the last two years all correlated significantly with the percent targets hit on Table VIII. The months he had served as

TABLE 9

CREW TURBULENCE BY DUTY POSITION

FOR THE 9 WEEK TIME PERIOD PRIOR TO GUNNERY QUALIFICATIONS

Crew Member Position	TYPE OF TURBULENCE (N=54 Crews)			
	Duty Position Turbulence		Crew Personnel Turbulence	
	# of Changes	Percent Turbulence	# of Changes	Percent Turbulence
Tank Commander	19	35%	18	33%
Gunner	26	48%	19	35%
Loader	34	63%	26	48%
Driver	30	56%	18	33%
Overall[1]	109	50%	81	38%

[1]Considering the tank crew as a unit, 47 of 54 crews (87%) experienced some form of turbulence in this time frame.

TABLE 10

CREW EXPERIENCE DESCRIPTIVE STATISTICS

EXPERIENCE (N=)	MEAN	MEDIAN	S.D.
Months crew together (51)	1.8	1.2	1.99
Months TC and Gunner together (50)	3.1	1.9	2.84
Months TC in Company (52)	13.7	12.0	11.63
Months as TC on M60 tanks (52)[1]	36.8	24.5	33.50
Months any position on M60 tanks (51)[1]	52.0	48.3	33.90
Number of gunnery tables fired by TC over last 2 years (53)			
Table VI	2.5	2.4	2.05
Table VII	2.5	2.1	2.11
Table VIII	2.0	1.8	1.95
Table IX	1.3	1.0	1.34
Months Gunner in Company (52)	9.6	7.5	8.42
Months as Gunner on M60 tanks (50)	17.6	12.3	16.61
Months any position on M60 tanks (52)	33.3	29.8	18.79
Number of gunnery tables fired over last 2 years (53)			
Table VI	1.5	0.8	1.85
Table VII	1.5	0.9	1.75
Table VIII	1.4	0.9	1.63
Table IX	1.0	0.7	1.04

[1]Because of 2 digit coding method used, all experience items were truncated at 99 months. On the two items indicated, 5 TCs had more than 99 months as TC and 9 had more than 99 months on M60 tanks. The averages, therefore, on these two items are somewhat underestimated.

TABLE 11

CORRELATIONS BETWEEN CREW EXPERIENCE
AND CRITERION GUNNERY PERFORMANCE MEASURES

TABLE VIII

Experience[1]	% Hits	% FR Hits	% Targets Hits	% Successful Engagements	Opening[2] Time	Total[2] Time
Months crew together	.16	.11	.12	.20	.04	-.10
Months TC and GNR together	.13	.05	.12	.13	.12	-.07
Months TC in Company	-.06	-.09	-.08	.03	.00	-.23
Months as TC on M60s	-.21	-.17	-.19	-.19	-.17	-.15
Months any position on M60s	-.19	-.12	-.18	-.21	-.09	-.15
Combined Gunnery tables fired by TC	.03	.03	-.07	-.01	-.04	-.16
Months GNR in Company	.27	.18	.33*	.10	-.21	-.25
Months as GNR on M60s	.33*	.23	.41**	.19	-.16	-.25
Months any position on M60s	.11	.03	.21	.13	-.08	-.10
Combined Gunnery tables fired by GNR	.22	.19	.31*	.18	-.20	-.05

$45 \leq N \leq 49$

[1]Natural log transformations used.

[2]A negative relationship between performance time and experience indicates better performance, i.e., performance time decreases as experience increases.

*$p < .05$ two tailed

**$p < .01$ two tailed

a Gunner on M60 tanks also correlated significantly with Table VIII percent hits.

For comparison purposes the raw scores on the experience measures were also directly correlated with the gunnery measures. The results showed no statistically significant correlations among any of the measures.

Job Experience Related to Training Task Performance

The data in the preceding section examined the relationship between the amount of job experience and performance on Gunnery Table VIII. A similar question could be asked with respect to the relationship between experience and performance on the training tasks. To examine this relationship correlation coefficients were computed separately between TC and Gunner experience measures and training task performance. TC experience measures were correlated with tasks in which the TC participated and Gunner experience measures were likewise correlated only with tasks related to the Gunner. Log transformations of the experience measures were again used.

The results are shown in Table 12. Again, as was found with the Table VIII correlations, the length of time that the TC and Gunner had been assigned together did not significantly correlate with either of the team performance measures; namely, 1/60 scale and 1/20 scale simulated engagements. The only significant relationships found between Tank Commander experience and training performance were negative relationships between percent first round hits on the 1/20 scale engagements, and the months the TC had been a TC on M60 tanks and the length of time he had served in any position on M60 tanks.

The correlations between Gunner experience and training performance resulted in a number of statistically significant correlations. The months that the Gunner had been a Gunner on M60 tanks correlated significantly and positively with both accuracy measures on the 1/60 scale cal. 22 engagements. This experience measure also related significantly to total time on the cal. 22 engagements, showing that as experience increased, the time required to complete an engagement decreased. The Gunner's past experience in firing live fire gunnery tables also correlated significantly with all of the 1/60 scale performance measures. Finally, experience on gunnery tables correlated significantly with the two Gunner paper and pencil tests, initial lay of the sight reticale and Gunner fire adjustment.

The fact that Gunner experience relates to both criterion gunnery performance and performance on the training tasks raises the possibility that past experience is a third variable which accounts for most of the variance in the relationship between training performance and Table VIII performance. To test this possibility partial correlation coefficients were computed between corresponding performance measures on 1/60 scale cal. 22 and Table VIII. Partial correlation is a statistical technique which correlates two variables and nullifies the effects of a third variable

TABLE 12
CORRELATIONS BETWEEN CREW EXPERIENCE
AND SELECTED TRAINING PREDICTORS

I. TANK COMMANDER TRAINING TASKS

TC Experience[1]	TC Fire Adj.	Ranging Error Rangefinder	Ranging Error Unaided	1/60 Scale % Hits	1/60 Scale % FR Hits	1/60 Scale Open[2] Time	1/60 Scale Total[2] Time	1/20 Scale % Hits	1/20 Scale % FR Hits	1/20 Scale Open[2] Time	1/20 Scale Total[2] Time
Months TC + GNR together	NA	NA	NA	.00	.05	.05	-.12	-.02	-.07	-.13	-.05
Months TC in Company	.05	.01	.02	.06	.11	.16	.00	-.04	-.07	.16	.13
Months as TC on M60s	-.10	.09	-.19	-.15	-.06	.20	.09	-.21	-.35*	-.10	-.07
Months any position on M60s	-.06	.20	-.26	-.01	.05	.23	.20	-.20	-.34*	-.06	-.02
Combined gunnery tables fired by TC	-.03	-.06	-.15	.05	.12	-.03	-.03	.01	-.06	.27	.29

II. GUNNER TRAINING TASKS

GNR Experience[1]	Initial Lay	GNR Fire Adj.	Stat. Tgts. Hit	Stat.[2] Tgt. Time	Moving Tgts. Hit	Moving[2] Tgt. Time	1/60 Scale % Hits	1/60 Scale % FR Hits	1/60 Scale Open Time	1/60 Scale Total Time	1/20 Scale % Hits	1/20 Scale % FR Hits	1/20 Scale Open Time	1/20 Scale Total Time
Months GNR in Company	.20	.09	.02	-.02	.13	-.01	.23	.24	-.10	-.18	.00	-.07	-.29	-.23
Months as GNR on M60s	.05	.15	.09	-.10	.17	.07	.35*	.35*	-.28	-.43**	.15	.07	-.09	-.10
Months any position on M60s	.00	.08	.22	.15	.17	-.10	.20	.20	-.12	-.28	-.04	-.12	-.14	.01
Combined gunnery tables fired by GNR	.37**	.37**	.07	-.15	.09	-.15	.41**	.36*	-.34*	-.65**	.18	.14	-.18	-.29

$26 \leq N \leq 50$

[1]Natural log transformations used.

[2]A negative relationship between performance time and experience indicates better performance, i.e., performance time decreases as experience increases.

*$p < .05$ two tailed

**$p < .01$ two tailed

upon both variables being correlated. The effects of the third variable are statistically "partialed" out. In the present case the point of interest is whether 1/60 scale cal. 22 training measures will still correlate with criterion gunnery performance once the effects of prior experience are removed.

Table 13 summarizes the partial correlations between 1/60 scale measures and Table VIII measures. The measures originally correlated and their zero order Pearson correlation coefficients are shown in the left hand column of the table. Three of these measures between cal. 22 and Table VIII were significantly related: percent first round hits, opening time and total time. The right side of the table shows the partial correlations for all of the measures after controlling for the experience variables. As the partial correlations clearly show, removing the effects of experience has a very limited effect on the relationship between cal. 22 performance measures and Table VIII performance. Removing the Gunner's experience as a Gunner on M60 tanks reduces somewhat the correlation between percent hits (.082 reduction), percent first round hits (.038), and total time (.058), but leaves the opening time correlation virtually unaffected (.003). Removing the effects of prior experience on gunnery tables has no affect on the accuracy and opening time correlations; however, the correlation between total times is increased (r=.341 vs. r=.489). Finally, the second order partial correlations (which allow the control of both experience variables simultaneously) again show a limited effect on accuracy and opening time correlations and an increase in the size of the correlation between total times. Overall it could be concluded that although experience relates to performance in both subcaliber training and Table VIII, the significant relationship between 1/60 scale subcaliber performance and Table VIII is independent of prior experience.

RELATIONSHIP OF ATTITUDES AND TANK GUNNERY PERFORMANCE

The final set of predictor variables that were related to criterion gunnery performance consisted of organizational climate and leadership measures. Organizational climate was assessed using the GOQ which contained the four scales identified by Sterling and Mietus (1979): Unit Climate, Supervisory Leadership, Group Cohesion, and Mission Accomplishment. The LBDQ-12 consisting of two scales, Initiating Structure and Consideration, was used to assess crew members' attitudes about their leaders. Both questionnaires were administered to all crew members including the Loader and Driver. Responses to all questionnaire items were scaled along a five point agreement dimension going from (1) strongly disagree to (5) strongly agree. The scale values of the responses for each subject were grouped into their respective quesionnaire attitude categories and mean values computed. These values were then used for data analysis purposes.

Initial data analysis focused on Tank Commander and Gunner attitudes as they related to Table VIII performance. Table 14 contains the correlations

TABLE 13

PARTIAL CORRELATIONS BETWEEN 1/60 SCALE CAL. 22

PERFORMANCE MEASURES AND TABLE VIII PERFORMANCE MEASURES

	Partial Correlations Controlling for Experience Variables		
	First order partials[1]		Second[1] order partials
Zero order correlations between 1/60 scale measures and Table VIII measures	a. Months as GNR on M60 tanks	b. # of times GNR fired gunnery tables	a. + b. Combined
% Hits r=.323	pr=.241	pr=.298	pr=.270
% First-Round Hits r=.387*	pr=.349	pr=.374*	pr=.356
$\bar{x}$ Opening Time r=.401*	pr=.398*	pr=.400*	pr=.397*
$\bar{x}$ Total Time r=.341*	pr=.283	pr=.489*	pr=.515**

N=33

*$p<.05$ two tailed

**$p<.01$ two tailed

[1]The variables indicated in the column heading were partialed out of the correlations between cal. 22 and Table VIII measures.

TABLE 14

CORRELATIONS BETWEEN TANK COMMANDER AND GUNNER ATTITUDE MEASURES AND CRITERION GUNNERY PERFORMANCE MEASURES

TABLE VIII

ATTITUDE VARIABLES	CREW MEMBER	% Hits	% FR Hits	% Targets Hit	% Successful Engagements	Opening Time	Total Time
GOQ							
UNIT CLIMATE	TC	.18	.01	.18	.13	-.01	.17
	GNR	-.12	.01	-.13	-.23	-.02	.10
SUPERVISORY LEADERSHIP	TC	.16	-.04	.13	.04	-.09	.02
	GNR	-.03	.04	-.02	-.05	-.09	.10
GROUP COHESION	TC	.21	.08	.29*[1]	.20	-.23	-.09
	GNR	.17	.27	.14	.15	-.17	-.05
MISSION ACCOMPLISHMENT	TC	.15	.02	.24	.07	-.12	-.03
	GNR	.04	.12	.04	.00	-.10	.06
LBDQ							
INITIATING STRUCTURE	TC	.08	-.07	.06	.02	.22	.17
	GNR	-.07	.12	-.10	-.09	.04	.08
CONSIDERATION	TC	-.13	-.14	-.19[2]	-.05	.16	.30*[1]
	GNR	.01	.17	.04	.07	.00	.03
Significant Multiple Rs= (selection criterion for entry F=2.84, $p<.10$)				R=.43**			R=.30*

N (all correlations) = 49

[1,2]Numbers indicate order in which variables were selected into multiple regression

*$p<.05$

**$p<.01$

between each of the attitude scales for both TC and Gunner and the criterion performance measures. The zero order correlations showed two statistically significant relationships between Tank Commander attitudes and criterion performance. The first significant correlation was between the TC Group Cohesion scores and percent targets hit on Table VIII. The positive correlation shows that those crews in which the TC perceives the crew as being able to work together effectively and harmoniously as a team achieve a higher percent of target hits on Table VIII. The GOQ questionnaire items most directly related to the Group Cohesion scale are items 42-51, Appendix E.

The other significant correlation for TC attitudes was between the leadership consideration scale and Table VIII total time. It should be kept in mind that on the LBDQ the questions for Tank Commanders were directed toward their Company Commanders, while the questions for other members of the crew (GNR, LDR, DRV) were directed toward their Tank Commander. Although the correlation coefficient was positive, the relationship between leader's consideration and performance was actually negative, i.e., those crews in which the TC perceived the Company Commander as high in consideration also took the longest time to complete a gunnery engagement. It is interesting to note that all of the Table VIII performance measures related negatively to the TC Consideration scale. Items 1-15 of the LBDQ (Appendix D) were included in the Consideration scale. No significant correlations were found between any of the Gunner attitude measures and criterion performance.

To look at the combined relationship of attitude measures to criterion performance, multiple regression analyses were computed separately for TC and Gunner attitude scales and each of the performance measures. Stepwise multiple regressions were computed with a criterion for entry of $F=2.84$, which was approximately equivalent to $p<.10$. The multiple Rs essentially confirmed the relationships found in the zero order correlations. The lower portion of Table 14 shows the significant multiple correlations which resulted from the analysis. Again the TC Group Cohesion score correlated significantly with percent target hits, but the LBDQ Consideration scale was also selected in the multiple regression resulting in a multiple R for these two scales of $R=.43$, $p<.01$. The TC Consideration scale again correlated with total time, but no other scale correlations met the criterion for inclusion into the regression.

One of the basic assumptions in this study was that the performance of Tank Commanders and Gunners has the most direct and greatest influence on criterion gunnery performance. For this reason it was considered not particularly meaningful to evaluate the direct relationships between Loader and Driver attitudes and Table VIII performance. The combined attitudes of the crew, however, with respect to their unit and leader could have an influence on team performance which could be reflected in the gunnery scores.

To determine if the attitude measures of all crew members could be meaningfully combined, a complete intercorrelation matrix of all attitude measures for all crew members was computed. This is shown in Appendix K.

The matrix was examined to determine the degree to which attitude scores were correlated among members of the same crew. If crew members showed a high degree of agreement on the various attitude scales, it would then be reasonable to compute a crew score on a particular scale. Lack of consistency among crew member attitudes would argue against combining the score since the results would be difficult to interpret.

Inspection of the correlation coefficients between crew members for each attitude scale showed very little relationship between crew members' scores. On Unit Climate the intercorrelations among crew members ranged from .07 to .35; on Supervisory Leadership the range was -.03 to .29; on Group Cohesion, -.17 to .16; on Mission Accomplishment, -.02 to .17; on LBDQ Structure, -.20 to .24; and on LBDQ Consideration, -.07 to .19. The intercorrelations between the Gunner, Loader, and Driver on the two Leadership scales were of special interest since the Leadership items for these three crew members referred to their Tank Commander. Again there was a general lack of agreement in the scores (Structure correlations ranged from -.06 to .24 and Consideration correlations ranged from -.07 to .01). Because of the lack of correlation among crew member attitudes, it was considered inappropriate to combine their scores into a crew composite.

RELATIVE CONTRIBUTIONS OF SELECTED PREDICTOR VARIABLES TO CRITERION GUNNERY PERFORMANCE

The preceding analyses examined, independently, the relationships between training variables, experience variables, attitudinal variables and criterion gunnery performance. An obvious question of interest concerns the relative contributions of all three types of variables in predicting gunnery performance. To answer this question a set of multiple regression analyses were conducted which included selected measures from the three sets of variables.

The predictor variable measures selected for the regression analyses were those which showed the strongest relationship to the criterion performance measures in the previous analyses. Thus the measures for the training variables selected were those shown in Part II of Table 8. The experience measures consisted of the months the Gunner served as a Gunner on M60 tanks and the total number of live fire gunnery tables fired by the Gunner. Table 11 showed that these two variables had the strongest relationship to criterion performance. The attitudinal variables were selected on the basis of the results shown in Table 14. These showed that TC Group Cohesion scores and Consideration scores both correlated significantly with selected Table VIII measures. The corresponding scores on the same two attitude variables for the Gunner were also included in the regression in order to have a representation of Gunner attitudes.

The Table VIII performance measures for which each regression was computed were again those shown in Table 8, Part II. A step-wise multiple

regression analysis was conducted for each of the five Table VIII dependent variables using the best set of predictor variables for each analysis. The sets of predictor variables used for each dependent variable were as follows. The two Gunner experience measures and four attitude measures (2 TC, 2 GNR) were used in each regression. In addition, the training measures used with each Table VIII dependent variable were: (with percent hits) 1/60 scale opening time, 1/60 scale percent hits, and percent stationary targets hit; (with percent first round hits) 1/60 scale opening time and 1/60 scale first round hits; (with percent targets hit) 1/60 scale opening time, and percent stationary targets hit; (with opening time) 1/60 scale opening time; and (with total time) 1/60 scale total time and initial lay. As with previous multiple regression analyses, a criterion level was selected for entry of a variable into the regression ($F=2.89$, approximate probability of $p<.10$).

A summary of the significant multiple regressions is shown in Table 15. The results in Table 15 are very similar to those reported in Table 8, Part II. Again performance on the 1/60 scale cal. 22 engagements accounts for the greatest proportion of the variance in the regression equations. The results, with one exception, of the percent first round hits, percent targets hit, and opening time regressions are identical to those shown in Table 8, Part II. The exception is that in the percent first round hit regression the order in which the two independent variables were selected was reversed. With percent hits as the dependent variable only one independent variable, 1/60 scale percent first round hits, met the entry criterion, and this resulted in a significant correlation. Finally, total time on the 1/60 scale engagements again correlated significantly with Table VIII total time; however, the Tank Commander Leadership Consideration score was also selected as contributing significantly to the total explained variance. The reader should keep in mind that each regression analysis was computed using an equal number of cases for all variables. This resulted in a smaller total N (range 31 to 33) in the regressions as compared to the zero order correlations shown in Tables 11 and 14. The smaller N was due to the limited number of 1/60 scale performance measures available. It is therefore possible that more of the experience and attitudinal variables would have been selected in the regressions if all the cases for these two variables had been used.

TABLE 15

SUMMARY OF SIGNIFICANT MULTIPLE REGRESSION
ANALYSES FOR PREDICTING GUNNERY PERFORMANCE
FROM SELECTED TRAINING, EXPERIENCE, AND ATTITUDE VARIABLES

Table VIII Dependent Variable	Variable Entered[1]	B	Individual F	Multiple R	R^2	R^2 Change	Simple R	Overall F
% Hits	1/60 Scale % FR Hits	.225	4.22	.356	.127	.127	.356	4.22*
% FR Hits	1/60 Scale FR Hits	.300	6.69	.387	.149	.149	.387	
	1/60 Scale Opening Time	-1.741	3.53	.489	.239	.089	-.263	4.72*
% Targets Hit	1/60 Scale Opening Time	-3.111	11.01	.448	.200	.200	-.448	
	Stationary Tgts. Hit	.402	3.47	.537	.288	.088	.096	5.68**
Opening Time	1/60 Scale Opening Time	.330	5.93	.400	.160	.160	.400	5.93*
Total Time	1/60 Scale Total Time	.254	4.57	.382	.146	.146	.382	
	TC Consideration	3.307	4.22	.508	.258	.112	.370	4.87*

$31 \leq N \leq 33$

*$p < .05$ two tailed

**$p < .01$ two tailed

[1]Criterion for Entry F=?.89, $p < .10$. Independent variables used in each regression are explained in the text.

DISCUSSION

The primary purpose of this study was to investigate the criterion related validity of critical training tasks contained in the Tank Gunnery Training Program for USAREUR Units. Crew member experience and attitudinal measures were also evaluated to determine their potential for predicting gunnery performance. Tank Commander and Gunner measures of training task performance, job experience, and attitudes were correlated singly and in combination with various Table VIII gunnery performance measures. The findings are discussed below.

TRAINING TASKS AND GUNNERY PERFORMANCE

A number of significant relationships were found between performance on training program tasks and Table VIII criterion performance. Considering first those training tasks performed individually by either the Gunner or Tank Commander, the zero order correlations showed that the ability of Gunners to track and hit moving targets using the M55 laser simulator related positively and significantly to the accuracy scores achieved on Table VIII. That is, Gunners hitting a higher percentage of moving targets with the simulator also used fewer rounds to hit targets on Table VIII (percent hits), achieved a higher percentage of targets hit, and had a greater percentage of Table VIII engagements in which all the targets were hit. Accuracy in hitting stationary targets with the laser simulator was significantly and positively correlated with the mean total time on the Table VIII engagements indicating that increased accuracy with the simulator was related to longer engagement times on the criterion test. There was also a significant positive relationship between the mean time per trial on this training task and mean opening time on Table VIII.

That accuracy and speed on training tasks are positively related to accuracy and speed, respectively, on the criterion tasks is a straightforward relationship which requires no additional interpretation. The relationship between higher accuracy on the stationary target tasks and increased total engagement time on the criterion is difficult to explain, especially in light of the fact that the intercorrelation (Appendix J) between stationary target accuracy and time scores show no relationship. One possible explanation of this relationship involves the instructions given to the Gunners on the stationary target task. It was observed early on that some Gunners had a tendency to traverse the turret very quickly across the stationary targets and to fire at the targets as they skimmed by. Their instructions were that they were being scored on both speed and accuracy. After observing a few cases of this behavior, additional instructions were given to the Gunners which emphasized that they were to make a correct lay on each target, that is a roughly G pattern with the final lay in an upward direction. It is possible that these latter instructions had a differential effect on less experienced or poorer Gunners such that they took more time and achieved a

greater number of hits than normally would be the case. On the criterion test it would be expected that poorer Gunners would also take a longer time on an engagement. The positive relationship between accuracy on the training task and length of time on Table VIII engagements may then have been an artifact largely related to the performance of the poorer Gunners.

No relationships were found between Tank Commander training tasks (ranging and knowledge of fire adjustment techniques) and gunnery performance. An earlier study by Eaton (1978) also found no correlation between TC ranging ability and gunnery performance. Furthermore, there were no relationships between Gunners' knowledge of initial lay, and fire adjustment procedures and Table VIII performance. The results suggest that these particular tasks are not valid training tasks in the sense that performance on them is unrelated to performance on the qualification table. To eliminate these tasks from training, however, would be a mistake. Comparing the skills involved in these tasks to ultimate criterion performance, namely, engaging an enemy in combat, it seems obvious that they have a high degree of face validity and criticality. In combat, situations will arise which will require the Tank Commander to range to targets and to give appropriate fire adjustment commands. Likewise, the Gunner will have to know how to use all of his fire control systems and engagement techniques to both achieve first round hits and adjust fire after a miss on stationary and moving targets. The reason that these apparently critical skills are not related to Table VIII performance is probably because there are no requirements to exercise them on the qualification table. Analysis of Table VIII engagements, discussions with tank crewmen, observation of the gunnery table, and listening to intra-tank communications support this view. With the exception of two targets which are beyond 1600 meters, all other targets on the USAREUR Table VIII are within battlesight gunnery range, and most are stationary targets. Even the two targets beyond this range are frequently engaged using either "extended" battlesight (aiming higher than the base of the target) or by pre-indexing the range into the computer based on an informed estimate of the range. Thus the need to range to any targets is effectively eliminated. Since most of the targets are engaged using battlesight techniques, the most appropriate and fastest fire adjustment technique is target form. Observation and discussions indicate that Gunners prefer target form or Burst on Target (BOT) adjustment techniques and that when the TC gives a fire adjustment command, which is not too often, it is a target form adjustment. Finally, there is no requirement on Table VIII to use the secondary fire control instruments (telescope), so that most, if not all, engagements are fired using the primary sight (periscope).

A breakout of performance by type of engagement conditions on the three paper and pencil tasks (Appendix H) showed that both Gunners and Tank Commanders are most proficient on the types of skills required on Table VIII and considerably less proficient on those not required. Highest proficiency was shown on battlesight engagements of stationary targets using the periscope, and BOT or target form fire adjustment techniques.

Work by Wheaton, Fingerman, and Boycan (1978) involving a sophisticated analysis of tank gunnery performance requirements resulted in the development of a Model Tank Gunnery Test which includes many of the types of engagement conditions not currently exercised on Table VIII. Based on their analysis, the test has a high degree of generalizability or content validity with respect to tank combat performance. Using this test, or one similar to it, for crew gunnery qualifications would more readily assure that all critical skills are being learned and also being exercised.

Turning now to training tasks consisting of simulated engagement methods involving both the TC and Gunner, the original purpose was to compare the methods to each other and to determine their relationship to Table VIII. The results of the zero order correlation analyses showed that speed and accuracy of performance on the 1/60 scale cal. 22 engagement method were significantly related to a number of corresponding performance measures on Table VIII. All relationships were in the direction that showed that better performance on the simulation method was related to better performance on the gunnery table. The Full Scale laser and 1/20 scale laser methods also showed some significant relationships to Table VIII; however, they were not as numerous nor as consistent in terms of accuracy measures correlating with Table VIII accuracy and speed measures correlating with Table VIII speed measures.

Two sets of multiple regression analyses were conducted which included as predictor variables either the 1/20 scale laser performance measures or the 1/60 scale cal. 22 performance measures along with additional selected TC or Gunner training task measures. The results clearly showed that, in terms of the variables entered, performance on the cal. 22 method accounted for a significantly greater proportion of the Table VIII performance variance than any of the other training measures. Specifically, cal. 22 opening time and percent first round hits were the best predictors of Table VIII accuracy while cal. 22 opening time and total time were respectively the best predictors of the corresponding Table VIII speed measures. These results would suggest that the best overall training predictor of Table VIII performance is performance on the subcaliber 1/60 scale simulation training range.

The statement above should be qualified somewhat by the following observation. Intercorrelations of the performance measures on the three simulation methods showed that none of the accuracy measures were significantly related, while some of the speed measures were significantly related, especially between 1/60 scale measures and the other two methods (Table 7). Furthermore, the zero order correlations between the three methods and the Table VIII criterion measures resulted in some significant relationships for all three methods between training performance times and Table VIII accuracy measures. Inspection of group accuracy measures (Table 3) for the three methods shows that the percent hits and percent first round hits for the Full Scale and the 1/20 scale engagements are not only considerably greater than for the 1/60 scale engagements, but they are fairly close to perfect performance (100 percent). What all of this may suggest is that performance in terms of accuracy measures on the two laser methods may have

approached a ceiling, thus limiting the possibility of discriminating between better and poorer performers and also reducing the size of the correlation coefficient among the methods, and between the methods and Table VIII.

That the time measures on the three methods significantly correlated with Table VIII accuracy suggests that there may be more of a relationship between these techniques and Table VIII than was found in the present study. Time scores are probably more variable and less subject to ceiling effects, especially under the present conditions, than accuracy measures. The ceiling effect for the accuracy measures may be masking a relationship between the laser method and criterion performance which could be observed if the difficulty level of the two tasks was increased.

The three methods as used in the present study were not equivalent in difficulty level. Both the Full Scale and the 1/20 scale methods used a laser which is inherently more accurate than the ballistic trajectory of a cal. 22 round. The Full Scale Engagements also did not employ moving targets. The 1/20 scale method and 1/60 scale method were exactly equivalent in terms of the engagements fired, number and types of targets, and simulated distance to the targets. The difficulty level of the two types of tasks were different however, on the basis of two factors. The first concerns sight parallax problems which are much greater on a 1/60 scale range than on a 1/20 scale range. Therefore, on a 1/60 scale range the Gunner has more difficulty getting an accurate sight picture. Secondly, the moving targets used on the 1/60 scale range were dragged across natural terrain while on the 1/20 scale range they were mounted on a flat rail and moved at a constant speed. Hitting moving targets on the 1/60 scale range was more difficult because of unexpected target movement induced by the terrain. These differences in difficulty probably contribute substantially to the lower accuracy scores on the 1/60 scale method.

A suggestion for future research would be to increase the difficulty level of the 1/20 scale engagements and again compare performance between the laser and subcaliber methods and relate both to live fire gunnery tables. It is possible that under these circumstances both methods would be equivalent predictors of live fire gunnery performance.

EXPERIENCE AND GUNNERY PERFORMANCE

Two types of experience measures were investigated in this study with respect to their relationship to Table VIII gunnery performance. The first type dealt with crew turbulence or the length of time crew members had been assigned together as a crew. The second type dealt with the amount of experience that Tank Commanders and Gunners had in their respective duty positions.

The data showed first of all that crew turbulence in an operational armor battalion was indeed high. During approximately a two-month period, 50 percent of the duty positions in the tanks were filled by different crew

members. Over the same period of time, 38 percent of the duty positions were filled by new crew members who had just joined the crew. At the time of Table VIII gunnery qualifications, the median length of time that a complete crew had been assigned together was 1.2 months. Tank Commander and Gunner pairs had been assigned together on the average of 1.9 months. Crew Turbulence is not a new phenomenon. Previous data reported by Eaton and Neff (1978) showed almost identical turbulence figures for several armor battalions (median time crews together, 1.2 months; TC and GNRs together, 2.6 months). There is considerable discussion currently among commanders and trainers with regard to the effects of crew turbulence, specifically whether turbulence is detrimental to training and gunnery performance.

The results of the present study showed that there was no relationship between either how long a crew had been assigned together or how long the TC and Gunner had been assigned together and how well that crew performed on Table VIII. These results would clearly support the view, at least in terms of gunnery qualifications, that turbulence is not directly related to gunnery performance. In a recent study by Drucker and Eaton (1979), platoon sergeants, platoon leaders, company commanders, and battalion commanders were asked to estimate the effects of crew turbulence on both training and unit gunnery performance. Their findings showed that turbulence was estimated to have no effect on tank crew or platoon gunnery qualifications and only a modest detrimental effect on training. Interestingly, platoon leaders and platoon sergeants (both of whom have the primary first line responsibility for training) judged that position turbulence has a positive effect on training because it provides an opportunity for cross training. Battalion commanders and company commanders, on the other hand, felt that the effect was slightly negative because turbulence disrupts crews which may cause a loss in pride and cohesion in the crew. The present study supports the judgement that turbulence has no direct effect on gunnery performance.

The results of the analyses relating TC and Gunner job experience to Table VIII performance showed that none of the Tank Commander experience measures were significantly related to any of the criterion performance measures. This finding supports a previous suggestion that the qualification table may not require the TC to exercise his skills completely. The amount of experience that the Gunner had in terms of time in the company, times as a Gunner on M60 tanks, and number of previous gunnery tables fired, all related significantly to Table VIII accuracy measures. Increased experience was related to greater accuracy on the table.

Additional analyses also examined the relationship between experience and training task performance. Again, the time that the TC and Gunner had served together was unrelated to performance. With the exception of two cases, TC experience was also unrelated to training task performance. The same two Gunner experience measures that correlated with Table VIII were, however, significantly related to a number of training task measures, especially performance measures on the 1/60 scale cal. 22 engagements. A subsequent analysis using partial correlations (Table 13) established

that the relationship between performance on the 1/60 scale engagements and criterion performance was largely independent of the Gunners' previous experience.

The findings in this study with respect to the relationship between job experience and performance can be briefly summarized as follows. Crew turbulence was unrelated to either training task performance or gunnery performance. Tank Commander experience was likewise unrelated to training and gunnery measures. Gunner experience was related to both training performance and Table VIII performance and this relationship did not seem to affect the independent relationships between training task performance and Table VIII performance.

ATTITUDES AND GUNNERY PERFORMANCE

The GOQ and LBDQ-12 were used to assess Tank Commander and Gunner attitudes with respect to Organizational Climate and Leadership. Scale scores derived from these instruments for both the TC and Gunner were correlated with the Table VIII performance measures. The results of both zero order correlations and multiple correlations showed that two attitude variables, on the part of the Tank Commander, related significantly to gunnery performance. The analyses showed the TCs perception of Group Cohesion related positively to accuracy on Table VIII. Somewhat surprisingly, the Tank Commanders' perception of the degree of consideration shown by his leader was negatively related to gunnery performance. No significant relationships were found between Gunner attitudes and Table VIII performance. Further analyses established that while crew members tended to be consistent in their attitudes across the different variables measured, there was virtually no agreement among crew members in a crew with regard to a particular attitude variable.

The Group Cohesion attitude scale contained items that dealt with how well crew members worked together, how supportive they were of each other's efforts, and the degree of trust and cooperation which exists in the crew. Since the Tank Commander is the leader of the crew and has primary responsibility for crew training and functioning, he would also be the primary figure involved in establishing group cohesion. The fact that high degrees of group cohesion, as perceived by the TC, related to better gunnery performance may suggest that (a) group cohesion is an important contributor to effective crew performance, and (b) the Tank Commander is in the best position to control and evaluate the degree of cohesion which exists.

The final analysis conducted in the study examined the relative contributions of training variables, experience variables, and attitude variables, to Table VIII performance. The results supported earlier findings that performance on the 1/60 scale subcaliber training tasks were the best predictors of Table VIII criterion gunnery performance.

In summary, the present study found that several of the tasks in the tank crew Gunnery Training Program have Table VIII criterion related validity. The tasks that were found to be unrelated to Table VIII may not necessarily be invalid training tasks because there is evidence to suggest that the current Table VIII may not be a valid measure of criterion gunnery performance. Performance on 1/60 scale subcaliber engagements was found to be the best predictor of Table VIII performance. In general, speed and accuracy measures on training tasks were related respectively to speed and accuracy measures on Table VIII performance. The data showed no best measures of Table VIII performance and future studies should continue to use multiple performance measures to get the most complete overall picture of performance. Gunner job experience was found to be an independent predictor of both training and gunnery performance; however, when combined with subcaliber training performance, the latter was selected as the better predictor. Finally, the data showed that Tank Commander attitudes, especially with respect to group cohesion and Leadership Consideration, were related to gunnery performance. The meaning and implications of these relationships need further clarification.

A few words of caution are in order with respect to the interpretation and utilization of the results of this study. A major limitation of the study was the relatively small sample of cases involved in the data analysis. Sample size is an inherent problem in field operational research and one that is difficult to overcome. It is probably unrealistic to assume that in military field research a sufficient sample size will ever be available to meet the statistical requirements for external validity and generalizability of the results. Statisticians themselves disagree as to what is an appropriate sample size with respect to multivariate analysis and establishing criterion related validity. Suggestions for the ratio of subjects to variables necessary for multivariate analysis range from 10:1 (Kunce, Cook, & Miller, 1975) to 40:1 (Cohen & Cohen, 1975). Schmidt and Hunter (1980) go further

and suggest that the sample size required to produce acceptable levels of statistical power in validation studies is considerably greater than the normally accepted 30 to 50 necessary for small sample statistics.

What this suggests is that the results of this study, and similar small sample studies, should be interpreted as being descriptive and suggestive of relationships and effects. They should not be interpreted as being automatically generalizable to a larger or a different population. The generalizability of results and establishment of valid relationships will have to await the replication of results from several small sample studies.

REFERENCES

Campbell, D. T., & Stanley, J. C. Experimental and Quasi-experimental Designs for Research. Chicago: Rand McNally and Company, 1966.

Cohen, J., & Cohen, P. Applied Multiple Regression/Correlation Analysis for the Behavioral Sciences. Hillsdale, New Jersey: Lawrence Erlbaum Associates, 1975.

Drucker, E. H., & Eaton, N. K. The fifth tank crewman survey: The impact of additional tank crewmen on reported performance in armor units. Human Resources Research Organization, Final Report 79-17, December 1979.

Eaton, N. K. Predicting tank gunnery performance. Army Research Institute Research Memorandum 78-6, February 1978.

Eaton, N. K., Bessemer, D. W., & Kristiansen, D. M. Tank crew position assignment. Army Research Institute Technical Report 391, October 1979.

Eaton, N. K., & Johnson, J. R. Job samples as tank gunnery performance predictors. Army Research Institute Working Paper FKFU79-1, May 1979.

Eaton, N. K., & Neff, J. R. The effects of tank crew turbulence on tank gunnery performance. Army Research Institute Technical Paper 350, September 1978.

Guion, R. M. Principles of work sample testing: II. Evaluation of personnel testing programs. Army Research Institute Technical Report TR-79-A9, April 1979.

Halpin, A. W., & Winer, B. J. A factorial study of the leader behavior descriptions. In R. M. Stodgill and A. E. Coons (Eds.), Leadership Behavior: Its Description and Measurement. Columbus: Ohio State University, 1957.

Hemphill, J. K., & Coons, A. E. Development of the Leader Behavior Description Questionnaire. In R. M. Stodgill and A. E. Coons (Eds.), Leadership Behavior: Its Description and Measurement. Columbus: Ohio State University, 1957.

Jeantheau, G. G., & Andersen, B. G. Training system use and effectiveness evaluation. U. S. Navy Training Device Center Technical Report: NAVTRADEVCEN 1743-1, July 1966.

Kunce, J. T., Cook, D. W., & Miller, D. E. Random variables and correlational overkill. Educational and Psychological Measurement, 1975, 35, 529-534.

O'Brien, R. E., Crum, W. J., Healy, R. D., Harris, J. H., & Osborn, W. D. Trial implementations of the Tank Crewman Skills Training Program (TCST). Army Research Institute Technical Report TR-78-A29, September 1978.

Schmidt, F. L., & Hunter, J. E. The future of criterion-related validity. Personnel Psychology, 1980, 33, 41-60.

Sharon, B., Kress, G., & McGuire, W. J. Integrated tank gunnery training program outline for USAREUR units. Final Report, Human Resources Research Organization, June 1980.

Sterling, B., & Mietus, J. R. Factor analysis of primary scales of the General Organizational Questionnaire. Draft Report. U. S. Army Research Institute for the Behavioral and Social Sciences, 1979.

Taylor, J. C., & Bowers, D. G. Survey of Organizations. Ann Arbor, Michigan: Institute for Social Research, University of Michigan, 1972.

Vroom, V. H. Leadership. In M. D. Dunnette (Ed.) Handbook of Industrial and Organizational Psychology. Chicago: Rand McNally, 1976.

Wheaton, G. R., Fingerman, P. W., & Boycan, G. G. Development of a model tank gunnery test. Army Research Institute Technical Report. TR-78-A24, August 1978.

APPENDIX A

TASK 1. APPLY SIGHT RETICLE FOR INITIAL LAY

CONDITIONS APPLYING TO EACH OF THE 22 SIGHT PICTURES

		BATTLESIGHT		PRECISION	
		Computer Working	Computer Not Working	Computer Working	Computer Not Working
HEP	STATIONARY	1[1]	1	N/A[2]	1
	MOVING	1	1	N/A[2]	1
HEAT	STATIONARY	1	1	1	1
	MOVING	1	1	1	1
SABOT	STATIONARY	1	1	1	1
	MOVING	1	1	1	1

[1]Numbers in cells indicate how many engagements of this type were presented.

[2]HEP cannot accurately be fired at precision ranges using the M32 periscope.

SAMPLE EXERCISE TASK 1

GUNNER
SABOT
TANK
2200
FIRE

Center of mass _____ of Base of target _____

Lead applied (in mils) _____ or No lead _____

APPENDIX B

TASK 2. APPLY SIGHT RETICLE FOR FIRE ADJUSTMENT

CONDITIONS APPLYING TO EACH OF THE 24 SIGHT PICTURES

TYPE OF ADJUSTMENT	PERISCOPE			TELESCOPE		
	HEP	HEAT	SABOT	HEP	HEAT	SABOT
RANGE CHANGE IN MILS	1	1	1	N/A[1]	N/A[1]	N/A[1]
STANDARD ADJUSTMENT	1	1	1	1	1	1
TARGET FORM	1	1	1	1	1	2[3]
RANGE CHANGE IN METERS	N/A[2]	N/A[2]	N/A[2]	1	1	2[4]
B.O.T.		1	1	1	1	

[1]Range change using the telescope is calibrated in meters.

[2]Range change using the periscope is calibrated in mils.

[3]One precision, one battlesight

[4]One moving target, one stationary target

SAMPLE EXERCISE TASK 2

	PERISCOPE (M32)
	HEAT
	STATIONARY
SENSING:	SHORT RIGHT
TC'S	LEFT 2
COMMAND:	ADD 2
	FIRE

APPENDIX C

TASK 3. DETERMINE FIRE ADJUSTMENT

CONDITIONS APPLYING TO EACH OF THE 20 SIGHT PICTURES

TYPE OF ADJUSTMENT	PERISCOPE			TELESCOPE		
	HEP	HEAT	SABOT	HEP	HEAT	SABOT
PRECISION (ROUND VISIBLE)	1	1	1	1	1	1
TARGET FORM (ROUND VISIBLE)	1	1	1	1	1	1
STANDARD ADJUSTMENT (ROUND LOST)	2[1]	1	1	1	2[1]	1

[1]One target at battlesight range, one at precision range

SAMPLE EXERCISE TASK 3

PERISCOPE (M32)
SABOT
TARGET FORM

APPENDIX D

LBDQ

LEADERSHIP BEHAVIORS

THIS QUESTIONNAIRE IS INTENDED TO PROVIDE INFORMATION RELATED TO LEADERSHIP IN YOUR WORK UNIT.

IF THE RESULTS ARE TO BE HELPFUL, IT IS IMPORTANT THAT YOU ANSWER EACH QUESTION AS THOROUGHLY AND FRANKLY AS POSSIBLE. THIS IS NOT A TEST, THERE ARE NO RIGHT OR WRONG ANSWERS.

THE COMPLETED QUESTIONNAIRES WILL BE PROCESSED BY AUTOMATED EQUIPMENT WHICH WILL SUMMARIZE THE ANSWERS IN STATISTICAL FORM SO THAT INDIVIDUALS CANNOT BE IDENTIFIED. PLEASE DO NOT WRITE YOUR NAME ANYWHERE ON THE QUESTIONNAIRE OR ANSWER SHEET.

UPON COMPLETION, PLEASE RETURN THE QUESTIONNAIRE TOGETHER WITH THE ANSWER SHEET.

INSTRUCTIONS

1. Mark all answers on the answer sheet. If you do not find the exact answer that fits your case, use the one that is closest to it.

2. Remember, the value of the survey depends upon your being straightforward in answering the questionnaire. Your answer sheets are processed by automated equipment and no one from your command will see them.

3. Items are answered by marking your response on the answer sheet with an X as shown in the following example:

   Item # 22. He works without a plan.

Item number	Strongly disagree	Somewhat disagree	Neutral	Somewhat agree	Strongly agree
22.	1	X	3	4	5

   In this example the response was (2); I somewhat disagree that he works without a plan.

4. Please use the pencil provided.

   --Mark each answer clearly.
   --Erase cleanly any answer you wish to change.
   --Make no stray markings.

Answer Items 1-30 on the Answer Sheet

LEADERSHIP BEHAVIORS

* 1. The Tank Commander does personal favors for the men in the crew.

2. The Tank Commander does little things to make it pleasant to be a member of crew.

3. He is easy to understand.

4. He finds time to listen to listen to individuals in the crew.

5. He keeps to himself.

6. He looks out for the welfare of each individual in the crew.

7. He refuses to explain his actions.

8. He acts without consulting the men in the crew.

9. He is slow to accept new ideas.

10. He treats every member of the crew as his equal.

11. He is willing to make changes.

12. He is friendly and approachable.

13. He makes members of the crew feel at ease when talking with him.

14. He puts suggestions by the members of the crew into operation.

15. He gets approval from the men in the crew before going ahead.

16. The Tank Commander makes his attitude clear to the men.

17. The Tank Commander tries out his new ideas in the crew.

18. The Tank Commander rules with an iron hand.

19. He criticizes poor work.

20. He speaks in a manner not to be questioned.

21. He assigns individuals to specific tasks.

22. He works without a plan.

*Items on the Tank Commander's Leadership Questionnaire refer to the Company Commander.

23. He maintains definite standards of performance for the men.

24. He emphasizes meeting deadlines.

25. He encourages the following of standard procedures.

26. He makes sure his role in the crew is understood by the men.

27. He insists that individuals follow standard operating procedures.

28. He lets individuals know what is expected of them.

29. He sees to it that individuals do as good a job as they can.

30. He sees to it that the work of the crew is coordinated.

APPENDIX E

GOQ

ORGANIZATIONAL CLIMATE

THIS QUESTIONNAIRE IS INTENDED TO PROVIDE INFORMATION ABOUT HOW THE MEMBERS OF YOUR ORGANIZATION WORK TOGETHER.

IF THE RESULTS ARE TO BE HELPFUL, IT IS IMPORTANT THAT YOU ANSWER EACH QUESTION AS THOROUGHLY AND FRANKLY AS POSSIBLE. THIS IS NOT A TEST, THERE ARE NO RIGHT OR WRONG ANSWERS.

THE COMPLETED QUESTIONNAIRES WILL BE PROCESSED BY AUTOMATED EQUIPMENT WHICH WILL SUMMARIZE THE ANSWERS IN STATISTICAL FORM SO THAT INDIVIDUALS CANNOT BE IDENTIFIED. PLEASE DO NOT WRITE YOUR NAME ANYWHERE ON THE QUESTIONNAIRE OR ANSWER SHEET.

UPON COMPLETION, PLEASE RETURN THE QUESTIONNAIRE TOGETHER WITH THE ANSWER SHEET.

INSTRUCTIONS

1. Mark all answers on the answer sheet. If you do not find the exact answer that fits your case, use the one that is closest to it.

2. Remember, the value ofthe survey depends upon your being straightforward in answering the questionnaire. Your answer sheets are processed by automated equipment and no one from your command will see them.

3. Items are answered by marking your response on the answer sheet with an X as shown in the following example:

   Item # 51. I am able to influence my co-workers when we are making group decisions.

Item number	Strongly disagree	Somewhat disagree	Neutral	Somewhat agree	Strongly agree
51.	1	X	3	4	5

   In this example the response was (2); I somewhat disagree that I can influence my co-workers when we are making group decisions.

4. Please use the pencil provided.

   --Mark each answer clearly.
   --Erase cleanly any answer you wish to change.
   --Make no stray markings.

5. The particular meaning of some of the terms used in the questionnaire is given below:

   a. "This unit" refers to your company.
   b. "Your supervisor" is the person who gives you your day-to-day assignments and rates your performance. Typically, if you are a driver, gunner, or loader, your supervisor is the tank commander. If you are a tank commander, your supervisor is the platoon leader or company commander.
   c. "Your co-workers" refer to the people you associate with everyday in order to get the job done, e.g. your tank crew members.
   d. "Your work group" refers to the entire team of people, including your crew co-workers, your supervisor, and your platoon, who work for a common goal.

Answer items 1-65 on the answer sheet.

RESPONSE SCALE FOR ITEMS 1-65

1) Strongly disagree
2) Somewhat disagree
3) Neutral
4) Somewhat agree
5) Strongly agree

ITEMS ABOUT YOUR UNIT

1. The information I receive down through formal channels is generally accurate.

2. I get all the information I need about what is going on in other sections or departments in my unit.

3. Work priorities are established in line with the unit's objectives.

4. Meetings in this unit generally accomplish meaningful objectives.

5. Decisions are made in this unit at those levels where the most adequate information is available.

6. Decisions are made in this unit after getting information from those who actually do the job.

7. I get a sense of accomplishment from the work I do.

8. I look forward to coming to work everyday.

9. I want to contribute my best efforts to the unit's mission and my assigned tasks.

10. This unit has a real interest in the welfare of assigned personnel.

11. My job helps me to achieve my personal goals.

12. I have enough time off to take care of my personal and family needs.

13. My performance evaluations and efficiency reports have been helpful to me.

14. This unit places a high emphasis on accomplishing the mission.

15. Workload and time factors are taken into consideration in planning our work group assignments.

16. I would like to stay in this unit as long as I can.

RESPONSE SCALE FOR ITEMS 1-65

1) Strongly disagree
2) Somewhat disagree
3) Neutral
4) Somewhat agree
5) Strongly agree

17. My unit is respected on this post.

18. The job I have is a respected one on this post.

19. I am not afraid to make an occasional mistake.

20. My unit is willing to try new or improved methods of doing work.

21. There is enough emphasis on competition in this unit.

22. Rules in this unit are enforced.

23. My job is directly related to meeting the unit's goals.

24. This unit is able to respond to all the demands put on it to accomplish its mission.

ITEMS ABOUT YOUR SUPERVISOR

25. My supervisor lets me know when I have done my job well.

26. My supervisor makes it easy to tell him/her when things are not going as well as he/she expects.

27. When appropriate, my supervisor supports my decisions.

28. It is easy for me to get in to see my supervisor.

29. My supervisor emphasizes teamwork.

30. When there is disagreement, my supervisor encourages the people who work for him/her to openly discuss their differences.

31. I know what my work group is trying to accomplish.

32. My supervisor emphasizes mission accomplishment.

33. My supervisor encourages us to give our best effort.

34. My supervisor maintains high personal standards of performance.

RESPONSE SCALE FOR ITEMS 1-65

1) Strongly disagree
2) Somewhat disagree
3) Neutral
4) Somewhat agree
5) Strongly agree

35. Unless I ask for help, my supervisor lets me do my work without interfering.

36. My supervisor gives clear instructions when he/she assigns me a task.

37. My supervisor shows me how to improve my performance.

38. My supervisor helps me plan and schedule my work ahead of time.

39. My supervisor ensures that all required materials are available to accomplish the job.

40. My supervisor is able to be heard by and influence those above him/her.

41. My supervisor is highly regarded as a leader by members of my work group.

ITEMS ABOUT YOUR CO-WORKERS

42. My co-workers tell me when they think I have done a good job.

43. I have the trust and support of my co-workers.

44. My co-workers work together as a team.

45. My co-workers encourage each other to give their best effort.

46. My co-workers maintain high standards of performance.

47. Open and honest discussion is used when there are disagreements among my co-workers.

48. My co-workers provide the help I need so I can plan, organize and schedule work ahead of time.

49. My co-workers offer each other new ideas for solving job related problems.

50. I feel that I am given adequate authority to perform the tasks and responsibilities assigned to me.

51. I am able to influence my co-workers when we are making group decisions.

RESPONSE SCALE FOR ITEMS 1-65

1) Strongly disagree
2) Somewhat disagree
3) Neutral
4) Somewhat agree
5) Strongly agree

ITEMS ABOUT YOUR WORK GROUP

52. Information important to our work is widely exchanged within my work group.

53. My work group plans together and coordinates its efforts.

54. I understand what is expected of me on my job.

55. My work group is able to respond on short notice to heavy work demands placed upon it.

56. My work group meets all requirements placed on it by higher levels of command.

57. People in my work group work hard.

58. I am working in the job area for which I have been trained.

59. I am getting the training I need to take on more responsibility.

60. My supervisor is trained for his/her job.

61. My work group has sufficient qualified personnel to accomplish its mission.

62. Army standards of order and discipline are maintained in my work group.

63. Members of my work group reflect Army standards of military courtesy, appearance and grooming.

64. Cooperation is encouraged between work groups in my unit.

65. When I am doing a job that requires the assistance of another work group, I usually receive the help I need.

APPENDIX F

BACKGROUND QUESTIONNAIRE - TANK COMMANDER

(1.5)

NAME _____

TANK _____ (1.1,2)

COMPANY _____ (1.3)

CARD 1 (1.4)

RANK _____ (1.6,7)

MOS _____

1. What is the name of your current: GUNNER _____

   LOADER _____

   DRIVER _____

2. How long have you and your current gunner, loader, and driver been assigned together as a tank crew?

   Months _____ Weeks _____ (1.8-12)

3. How long have you and your current gunner been assigned together as TC and gunner?

   Months _____ Weeks _____ (1.13-17)

4. How long have you been a tank commander in your current company, regardless of crew?

   Years _____ Months _____ (1.18,19)

5. How long have you been a tank commander on M60 tanks regardless of tank company or crew?

   Years _____ Months _____ (1.20,21)

6. How long have you served on M60 tanks regardless of duty position, company, or crew?

   Years _____ Months _____ (1.22,23)

7. Over the last two years, how many times have you fired the main gun tank gunnery tables as either a TC or gunner?

   Table six _____ time(s) (1.24,25) Table eight _____ time(s) (1.28,29)

   Table seven _____ time(s) (1.26,27) Table nine _____ time(s) (1.30,31)

BACKGROUND QUESTIONNAIRE - GUNNER

(1.5)

NAME _____

TANK _____
(1.1,2)

COMPANY _____
(1.3)

CARD 1 (1.4)

RANK _____
(1.6,7)

MOS _____

1. How long have you been a gunner on a tank in your current company?

   Years _____ Months _____ _____
   (1.18,19)

2. How long have you been a gunner on M60 tanks regardless of tank company or crew?

   Years _____ Months _____ _____
   (1.20,21)

3. How long have you served on M60 tanks regardless of duty position, company, or crew?

   Years _____ Months _____ _____
   (1.22,23)

4. Over the last two years, how many times have you fired the main gun tank gunnery tables as a gunner?

   Table six _____ time(s)
   (1.24,25)

   Table seven _____ time(s)
   (1.26,27)

   Table eight _____ time(s)
   (1.28,29)

   Table nine _____ time(s)
   (1.30,31)

APPENDIX G

CREW COMBAT COURSE TABLE VII and VIII A & B

TANK COMMANDER _____ GUNNER _____ UNIT _____

DRIVER _____ LOADER _____ DATE _____ RANGE _____

DAY PHASE

TASK	CONDITIONS	TRAINING/EVALUATION STANDARDS
Engage one moving tank and one stationary tank with the main gun.	AMMO: 4 TPDS-T Tank to target range: 1200-1600m Moving Tank: #71 Stationary Tank #60 Crew must wear NBC gear and close hatches.	DISTINGUISHED 1. Engage and hit both targets. 2. Time allotted: 0-18 seconds. QUALIFIED 1. Engage and hit both targets. 2. Time allotted: 19-30 seconds. UNQUALIFIED 1. One target is missed. 2. Time exceeds 30 seconds.
Engage troops with coax, AT gun with .50 and HIND with .50.	AMMO: 100 7.62; 100 .50 Tank to target range: HIND 1200-1500m. Troops and AT gun 500-900m HIND: FM 17-12-7. AT gun: #44	DISTINGUISHED 1. Obtain 3/5 area coverage on troops: Hit HIND and AT gun. 2. Time allotted: 0-18 seconds. QUALIFIED 1. Obtain 2/5 coverage on troops: Hit HIND and AT gun. 2. Time allotted: 19-40 seconds. UNQUALIFIED 1. Less than 2/5 coverage on troops. 2. HIND or AT gun not hit. 3. Time exceeds 40 seconds.
Engage one stationary hull down tank with main gun in the STAB mode.	AMMO: 2 TPDS-T Tank to target range: 0800-1000m Target #60 Firing vehicle speed is greater than 8 MPH.	DISTINGUISHED 1. Engage and hit the target while on the move. 2. Time allotted: 0-11 seconds. QUALIFIED 1. Engage and hit the target while on the move 2. Time allotted: 12-16 seconds. UNQUALIFIED 1. The target is missed. 2. Time exceeds 16 seconds.

TASK	CONDITIONS	TRAINING/EVALUATION STANDARDS
Engage one moving truck with .50 cal and troops with coax.	AMMO: 100 7.62; 50 .50cal Tank to target range: 500-800m Truck:#43 Firing tank is stationary	DISTINGUISHED 1. Obtain 3/5 area coverage on troops and hit truck. 2. Time allotted: 0-12 seconds. QUALIFIED 1. Obtain 2/5 area coverage on troops and hit truck.(Time: 13-30 seconds) UNQUALIFIED 1. Less than 2/5 area coverage on troops or truck is missed. 2. Time exceeds 30 seconds.
Engage two threat tanks with the main gun and one HIND with the .50.	AMO 4 TPDS-T, 50 .50cal Tank to target range: Tanks: 1800-2000m. Tanks are 50-75m apart. HIND 1000-1400m Tanks: Hard Targets. HIND: FM17-12-7	DISTINGUISHED 1. Engage and hit both main gun targets and hit the HIND. 2. Time allotted: 0-28 seconds. QUALIFIED 1. Engage and hit both main gun targets and hit the HIND. 2. Time allotted: 29-40 seconds. UNQUALIFIED 1. Only one main gun target is hit or the HIND is missed. Time exceeds 40 seconds.
Engage a three tank Platoon with the main gun.	AMMO: 5 HEAT-TP-T Tank to target range: 800-1100m. Targets are 50-75m apart. Tanks: #70.	DISTINGUISHED 1. Engage and hit all three targets. 2. Time allotted: 0-26 seconds. QUALIFIED 1. Engage and hit all three targets. Time allotted: 27-40 seconds. UNQUALIFIED 1. One or more targets missed. 2. Time exceeds 40 seconds.

NIGHT PHASE

TASK	CONDITIONS	TRAINING/EVALUATION STANDARDS
Engage two stationary enemy tanks with main gun and one truck with .50cal MG using range card to direct fire techniques.	AMMO: 4 HEAT-TP-T,50 .50 IR Illumination or passive sight required. Crew must wear NBC gear and close hatches. Tank to turret range: 800-1000m, targets are 50-75m apart; truck 800-1000m. Tanks: #70 Truck: #43 When gunner lays the gun from the range card, the target will be in his sight but the gun will not be directly laid on the target. Gunner must use daylight direct fire techniques.	DISTINGUISHED 1. Engage and hit all targets. 2. Time allotted: 0-23 seconds. QUALIFIED 1. Engage and hit all targets. 2. Time allotted: 24-40 seconds. UNQUALIFIED 1. One or more targets missed. 2. Time exceeds 40 seconds.
Engage a stationary HIND with .50 cal and an infantry squad with coax.	AMMO: 100 7.62; 50 .50cal Indirect illumination. Tank to target range: Troops: 500-800m. Hind: 1000-1400m. HIND: FM 17-12-7. Firing tank is stationary.	DISTINGUISHED 1. Obtain 3/5 area coverage on troops with coax and hit the HIND with the .50. 2. Time allotted: 0-12 seconds. QUALIFIED 1. Obtain 2/5 area coverage on troops with coax and hit the HIND with the .50. Time allotted: 13-30 seconds. UNQUALIFIED 1. Less than 2/5 area coverage on the troops or HIND missed. 2. Time exceeds 30 seconds
Engage one moving tank and one stationary tank with the main gun	AMMO: 4 TPDS-T Indirect illumination. Tank to target range: 800-1200m. Moving tank: #71 Stationary tank: #59	DISTINGUISHED 1. Engage and hit both targets. 2. Time allotted: 0-18 seconds. QUALIFIED 1. Engage and hit both targets. 2. Time allotted: 19-40 seconds. UNQUALIFIED 1. Only one target is hit. 2. Time exceeds 40 seconds

TASK	CONDITIONS	TRAINING/EVALUATION STANDARDS
Ammo conservation	All previous tasks have been completed.	DISTINGUISHED 1. Return eight (8) or more main gun rounds. QUALIFIED 1. Return six or seven (6-7) main gun rounds. UNQUALIFIED 1. Return less than six (6) gun rounds.

1. To receive a DISTINGUISHED rating, the crew must obtain a DISTINGUISHED rating on 9 of 10 tasks.

2. To receive a QUALIFIED rating, the crew must obtain a DISTINGUISHED or QUALIFIED rating on 7 of 10 tasks.

3. A crew is UNQUALIFIED when it receives an UNQUALIFIED rating on 4 or more tasks.

# DISTINGUISHED	# QUALIFIED	# UNQUALIFIED
_____	_____	_____

OVERALL PROFICIENCY

DISTINGUISHED QUALIFIED UNQUALIFIED

TABLE VI A&B SCORE SHEET

M60A1		BEGIN TIME	END TIME
TANK NUMBER	TANK CMDR	LOADER	DATE
UNIT	GUNNER	DRIVER	
TASK: DAY PHASE	AMMO/CONDITION	STANDARD	
Task #1 Engage Two BMP's	4 rds HEP Range 1400	DISTINGUISHED 1. Engage and hit both targets. 2. Time: 0-24 seconds. QUALIFIED 1. Engage and hit both targets. 2. Time: 25-40 seconds. REQUIRES IMPROVEMENT 1. Fail to hit one target. 2. Time exceeds 40 seconds.	
Task #2 Engage one moving tank and two stationary tanks.	5 TPDST Moving tank 1000 Stationary tank 1000 Stationary tank 1100	DISTINGUISHED 1. Engage and hit all targets. 2. Time: 0-15 seconds. QUALIFIED 1. Engage and hit all targets. 2. Time: 16-30 seconds. REQUIRES IMPROVEMENT 1. Fail to hit one target. 2. Time exceeds 30 seconds.	
Task #3 Engage Troops with coax. ATGM and HIND with 50 cal.	100 7.62 100 50 cal. HIND: 1200 ATGUN: 1200 TROOPS: 800	DISTINGUISHED 1. Engage and hit HIND and ATGUN. 2. Get 5/5 area coverage. 3. Time: 0-15 seconds. QUALIFIED 1. Engage and hit HIND and ATGUN 2. Get 4/5 area coverage. 3. Time: 16-20 seconds REQUIRES IMPROVEMENT 1. One target is not hit. 2. 3/5 area coverage 3. Time exceeds 20 seconds	

TASK	AMMO/CONDITION	STANDARD
Task #4 Engage one moving tank, one stationary tank, and one HIND.	3 TPDS-T 50- 50 cal. Moving: 1000 Stationary tank: 1200 HIND: 1200	DISTINGUISHED 1. Hit all targets. 2. Time: 0-18 seconds QUALIFIED 1. Hit all targets. 2. Time: 19-25 seconds. REQUIRES IMPROVEMENT 1. Fail to hit one target. 2. Time exceeds 25 seconds.
Task #5 Engage two tanks and one HIND.	3 TPDS-T 50-50 cal. Stationary Tank:1000-1200 HIND: 1600	DISTINGUISHED 1. Hit all targets. 2. Time 0-12 seconds. QUALIFIED 1. Hit all targets. 2. Time:13-18 seconds REQUIRES IMPROVEMENT 1. Fail to hit one target. 2. Time exceeds 18 seconds.
Task #6 Engage a three tank platoon.	5 HEAT Tanks: 1000-1200	DISTINGUISHED 1. Hit all targets. 2. Time: 0-20 seconds. QUALIFIED 1. Hit all targets. 2. Time: 20-30 seconds. REQUIRES IMPROVEMENT 1. Fail to hit one target. 2. Time exceeds 30 seconds.
Task #7 Engage one moving truck and troops.	50-50 cal. 100 coax. Truck: 1200 Troops: 800	DISTINGUISHED 1. Hit moving truck. 2. 5/5 area coverage on troops 3. Time: 0-12 seconds. QUALIFIED 1. Hit moving truck. 2. 4/5 area coverage. 3. Time: 13-16 seconds. REQUIRES IMPROVEMENT 1. Fail to hit moving truck. 2. 3/5 area coverage on troops. 3. Time exceeds 16 seconds

TASK: NIGHT PHASE	AMMO/CONDITION	STANDARD
Task #8 Engage one HIND and troops.	50-50 cal. 100 coax. HIND: 1200 Troops: 800 W/L or indirect illumination	DISTINGUISHED 1. Hit HIND. 2. 5/5 area coverage on troops. 3. Time allotted 0-12 seconds. QUALIFIED 1. Hit HIND. 2. 4/5 area coverage on troops. 3. Time allotted 13-16 seconds. REQUIRES IMPROVEMENT 1. Fail to hit HIND. 2. 3/5 area coverage on troops. 3. Time allotted 16 seconds.
Task #9 Engage one moving tank and one stationary BMP.	3 TPDS-T Moving tank: 1100 BMP: 1400	DISTINGUISHED 1. Hit all targets. 2. Time: 0-12 seconds. QUALIFIED 1. Hit all targets. 2. Time: 13-16 seconds. REQUIRES IMPROVEMENT 1. Fail to hit one target. 2. Time exceeds 16 seconds.
Task #10 Engage one tank.	2 HEP Tank: 1400 Indirect Illumination.	DISTINGUISHED 1. Hit all targets. 2. Time: 0-16 seconds. QUALIFIED 1. Hit all targets. 2. Time: 17-28 seconds. REQUIRES IMPROVEMENT 1. Fail to hit one target. 2. Time exceeds 28 seconds.
Task #11 Engage Two tanks and one truck.	3 HEAT 50-50 cal. Tanks: 1400-1600 Truck: 1400 IR	DISTINGUISHED 1. Hit all targets. 2. Time: 0-15 seconds. QUALIFIED 1. Hit all targets. 2. Time: 16-23 seconds. REQUIRES IMPROVEMENT 1. Fail to hit one target. 2. Time exceeds 23 seconds.

TASK	STANDARD
AMMO CONSERVATION	DISTINGUISHED - Bring back 7 rounds. QUALIFIED - Bring back 4 to 6 rounds. REQUIRES IMPROVEMENT - Bring back less than 4 rounds.

1. To receive a DISTINGUISHED rating, the crew must obtain a DISTINGUISHED rating on 10 of 11 tasks.

2. To receive a QUALIFIED rating, the crew must obtain a DISTINGUISHED or QUALIFIED rating on 8 of 11 tasks.

3. A crew is UNQUALIFIED when it receives an UNQUALIFIED rating on 4 or more tasks.

# DISTINGUISHED	# QUALIFIED	# UNQUALIFIED
_____	_____	_____

OVERALL PROFICIENCY

DISTINGUISHED QUALIFIED UNQUALIFIED

AMMO REQUIREMENTS

HEAT-TP-T	8
TPDS-T	14
HEP-TP-T	6
7.62mm	300
CAL.50	350

APPENDIX H

GROUP PERFORMANCE ON PAPER AND PENCIL TASKS

BROKEN OUT BY TYPE OF ENGAGEMENT CONDITIONS

Task 1. Apply Sight Reticle for Initial Lay (N=50)

Engagement Condition	Mean Percent Correct	S.D.
Moving target	30.10	20.96
Stationary target	52.02	25.43
Battlesight	39.86	22.05
Precision	41.34	28.37
Periscope	54.18	25.21
Telescope	26.64	23.54
	Overall = 40.62	22.00

Task 2. Fire Adjustment (GNR) N=47

Engagement Condition	Mean Percent Correct	S.D.
Periscope	49.89	24.73
Telescope	29.85	20.56
Moving target	36.85	22.21
Stationary target	41.64	20.41
B.O.T.	51.06	32.12
Mil change	46.28	37.22
Standard adjustment	32.02	25.48
Target form	38.28	23.09
Range change	34.75	29.25
	Overall = 39.57	19.70

Task 3. Fire Adjustment (TC) N=54

Engagement Condition	Mean Percent Correct	S.D.
Target form	52.48	33.62
Mil standard adj.	11.11	17.28
Mil change	32.43	31.23
Range change	12.26	18.58
Range standard adj.	19.91	22.97
	Overall = 28.70	13.29

APPENDIX I

GUNNERY PERFORMANCE INTERCORRELATION

MATRIX TABLES VI, VII, AND VIII

VARIABLE CODE	VARIABLE NAME	N	MEAN	S.D.
	TABLE VI			
TVITMG	Main Gun Hits	54	57.30	14.52
TVIFRH	Main Gun First-Round Hits	54	57.24	18.81
TVIMGH	Main Gun Targets Hit	54	82.44	11.69
TVIMAC	Machinegun Hits	46	78.30	19.30
	TABLE VII			
TVIITMG	Main Gun Hits	52	64.29	20.57
TVIIFRH	Main Gun First-Round Hits	52	62.12	22.83
TVIIMGH	Main Gun Targets Hit	52	83.85	17.79
TVIIMAC	Machinegun Hits	48	75.83	19.78
	TABLE VIII (DAY)			
T8DMG	Main Gun Hits	54	57.22	15.45
T8DFRH	Main Gun First-Round Hits	54	49.20	18.10
T8DMGH	Main Gun Targets Hit	54	73.93	15.79
T8DMAC	Machinegun Hits	52	66.67	17.29
T8DOT	Opening Time	54	7.00	2.41
T8DTT	Total Time	54	32.96	5.77

	TVITMG	TVIFRH	TVIMGH	TVIMAC	TVIITMG	TVIIFRH	TVIIMGH	TVIIMAC	T8DMG	T8DFRH	T8DMGH	T8DMAC	T8DOT	T8DTT
TVITMG	---													
TVIFRH	.90[3]	---												
TVIMGH	.87[3]	.71[3]	---											
TVIMAC	.13	.23	-.04	---										
TVIITMG	-.07	.03	-.11	-.01	---									
TVIIFRH	-.08	.02	-.14	-.03	.90[3]	---								
TVIIMGH	.00	.14	-.11	.20	.83[3]	.73[3]	---							
TVIIMAC	.27	.31[1]	.21	-.11	.21	.17	.14	---						
T8DMG	.07	.15	.00	.04	.19	.23	.24	.16	---					
T8DFRH	.00	.07	-.04	.03	.15	.23	.11	.10	.83[3]	---				
T8DMGH	-.04	.03	-.11	-.07	.18	.19	.18	.21	.87[3]	.74[3]	---			
T8DMAC	.08	.01	.00	-.16	.00	-.06	-.03	-.25	.12	.07	.19	---		
T8DOT	-.03	-.07	.09	.08	.01	-.02	-.04	-.04	-.17	-.07	-.33[1]	-.22	---	
T8DTT	-.16	-.27[1]	.01	-.03	-.20	-.22	-.25	-.19	-.45[3]	-.33[1]	-.52[3]	-.24	.48[3]	---

[1] $p < .05$ two tailed

[2] $p < .01$ two tailed

[3] $p < .001$ two tailed

APPENDIX J

INTERCORRELATION MATRIX OF TRAINING VARIABLES

AND TABLE VIII PERFORMANCE MEASURES

VARIABLE CODE	VARIABLE NAME	N	MEAN	S.D.
INITLAY	Initial Lay	46	41.26	21.91
FADJ	Fire Adjust (GNR)	44	39.18	20.09
TCADJF	Fire Adjust (TC)	50	29.30	13.59
T3C67	Stat. Target Time	46	3.74	1.21
STATGT	Stat. Targets Hit	46	84.50	11.16
T3C74	Moving Target Time	44	5.00	1.54
MVTGT	Moving Targets Hit	44	85.66	15.74
GUNRNG	Ranging (Rangefinder)	29	86.03	73.78
T4C66	Ranging (Unaided)	35	266.29	151.31
	Full Scale Engagements			
GUNTHT	Hits	36	85.81	12.39
GUNFRH	First-Round Hits	36	82.89	15.92
GUNOPN	Opening Time	36	13.61	3.32
GUNTOT	Total Time	36	23.14	5.05
	1/60 Scale Engagements			
C22THT	Hits	37	47.30	19.25
C22FR	First-Round Hits	37	50.95	20.86
C22OPN	Opening Time	37	9.08	2.69
C22TOT	Total Time	37	25.27	7.08
	1/20 Scale Engagements			
LSRTHT	Hits	36	76.56	14.66
LSRFR	First-Round Hits	36	83.36	15.53
LSROPN	Opening Time	36	7.47	1.16
LSRTOT	Total Time	36	15.75	2.78
	Table VIII Performance			
T8DNMG	Hits	53	56.49	13.64
T8DNFR	First-Round Hits	53	51.30	14.74
T8DNMGH	Targets Hit	53	73.28	14.98
CORRECT	Successful Engagements	53	49.47	15.62
T8DNOT	Opening Time	53	6.85	2.42
T8DNTT	Total Time	53	34.47	5.19

	INITLAY	FADJ	TCADJF	T3C67	STATGT	T3C74	MVTGT	GUNRNG	T4C66	GUNTHT	GUNFRH	GUNOPN	GUNTOT	C22THT	C22FR	C22OPN	C22TOT	LSRTHT	LSRFR	LSROPN	LSRTOT
INITLAY	---																				
FADJ	.53[3]	---																			
TCADJF	-.06	.01	---																		
T3C67	-.10	-.22	-.01	---																	
STATGT	.39[2]	.14	.14	.04	---																
T3C74	-.14	-.10	.18	.08	-.00	---															
MVTGT	.16	.28	.01	.10	.02	.24	---														
GUNRNG	-.13	-.06	-.12	-.07	-.06	.10	-.04	---													
T4C66	-.10	.02	.22	-.05	.08	.01	-.01	.13	---												
GUNTHT	.18	-.02	-.15	.04	.48[2]	-.12	-.02	.26	.29	---											
GUNFRH	.19	.04	-.22	-.08	.38[1]	-.25	-.10	.27	.19	.90[3]	---										
GUNOPN	.15	.06	.25	.08	.38[1]	.05	-.08	-.33	.13	.21	.23	---									
GUNTOT	.20	.12	.22	.04	.16	.19	-.02	-.46[1]	-.13	-.11	.01	.83[3]	---								
C22THT	.29	.00	.31	-.05	.12	-.02	-.18	.38	.04	.18	.12	-.12	-.20	---							
C22FR	.36[1]	.05	.32	.04	.14	.11	-.17	.40	-.09	.18	.09	-.04	-.09	.92[3]	---						
C22OPN	.14	-.04	.29	-.03	.46[2]	.18	-.36[1]	-.22	.10	.27	.15	.48[2]	.36	.05	.10	---					
C22TOT	-.09	-.16	.15	.06	.19	.51[2]	.06	-.28	-.01	.10	.04	.25	.26	-.37[1]	-.25	.56[3]	---				
LSRTHT	.02	.12	-.07	.12	-.22	-.09	.47[2]	.24	.23	.05	.06	-.39[1]	-.36	-.07	-.16	-.38[1]	-.30	---			
LSRFR	-.04	-.10	-.24	.01	-.27	-.06	.31	.24	.28	.04	-.01	-.50[2]	-.55[2]	-.03	-.22	-.49[2]	-.33	.84[3]	---		
LSROPN	.06	-.09	.25	.16	.23	.18	-.20	-.34	.10	.30	.16	.32	.35	.09	.15	.60[3]	.42[1]	-.21	-.37[1]	---	
LSRTOT	-.13	-.14	.16	.38[1]	.15	.22	-.35[1]	-.34	-.25	.15	-.01	.28	.29	.02	.15	.65[3]	.48[2]	-.60[3]	-.66[3]	.63[3]	---
T8DNMG	.03	.17	.12	.02	-.05	.11	.32[1]	.27	[illegible]3	.13	.15	-.29	-.20	.27	.32	-.27	-.26	.24	-.02	.06	-.15
T8DNFR	-.11	-.01	.09	.18	-.17	.03	.17	.34	[illegible]	.15	.14	-.39[1]	-.35[1]	.28	.33[1]	-.29	-.32	.25	.03	.08	-.07
T8DNMGH	.02	.12	.15	-.08	-.06	.01	.38[1]	.19	-.18	.03	.09	-.30	-.21	.17	.16	-.42[2]	-.35[1]	.37[1]	.18	-.14	-.44[2]
CORRECT	.06	-.04	.13	-.02	-.14	.22	.32[1]	.33	-.16	-.07	-.04	-.31	-.14	.36[1]	.35[1]	-.29	-.31	.15	.09	-.13	-.25
T8DNOT	-.05	-.24	.16	.33[1]	.16	.23	-.14	-.12	.21	.21	.05	.28	.22	.15	.22	.38[1]	.19	-.25	-.28	.46[2]	.65[3]
T8DNTT	.29	-.02	.00	.24	.33[1]	.03	-.04	-.29	.16	.20	.13	.38[1]	.28	-.23	-.15	.31	.34[1]	.06	-.01	.26	.17

	T8DNMG	T8DNFR	T8DNMGH	CORRECT	T8DNOT	T8DNTT
T8DNMG	---					
T8DNFR	.85[3]	---				
T8DNMGH	.88[3]	.75[3]	---			
CORRECT	.68[3]	.63[3]	.71[3]	---		
T8DNOT	-.19	-.10	-.44[3]	-.26	---	
T8DNTT	-.39[2]	-.37[2]	-.45[3]	-.44[3]	.54[3]	---

[1] $p < .05$

[2] $p < .01$

[3] $p < .001$

APPENDIX K

INTERCORRELATION MATRIX OF GOQ AND LBDQ SCALES
AND TABLE VIII PERFORMANCE MEASURES

VARIABLE CODE	VARIABLE NAME	N	MEAN	S.D.
TI	TC Unit Climate	37	3.33	0.77
TII	TC Sup. Ldrship	37	3.77	0.81
TIII	TC Group Cohesion	37	3.75	0.85
TIV	TC Mission Accom.	37	3.98	0.76
TV	TC Initiating Structure	37	3.36	0.64
TVI	TC Consideration	37	3.79	0.61
GI	GNR Unit Climate	37	2.63	0.83
GII	GNR Sup. Ldrship	37	3.13	1.10
GIII	GNR Group Cohesion	37	3.22	0.97
GIV	GNR Mission Accom.	37	3.35	0.87
GV	GNR Initiating Structure	37	3.41	1.07
GVI	GNR Consideration	37	3.61	0.86
LI	LDR Unit Climate	37	2.48	0.98
LII	LDR Sup. Ldrship	37	3.21	1.19
LIII	LDR Group Cohesion	37	3.00	1.09
LIV	LDR Mission Accom.	37	3.24	1.11
LV	LDR Initiating Structure	37	3.06	1.13
LVI	LDR Consideration	37	3.17	0.98
DI	DRVR Unit Climate	37	2.75	0.87
DII	DRVR Sup. Ldrship	37	3.42	0.85
DIII	DRVR Group Cohesion	37	3.23	0.81
DIV	DRVR Mission Accom.	37	3.49	0.70
DV	DRVR Initiating Structure	37	3.40	0.77
DVI	DRVR Consideration	37	3.55	0.63
	TABLE VIII PERFORMANCE			
T8DNMG	Main Gun Hits	37	54.86	14.51
T8DNFR	Main Gun First-Round Hits	37	48.78	15.05
T8DNMGH	Main Gun Targets Hit	37	70.92	1[illegible].61
T8DNOT	Opening Time	37	7.27	2.47
T8DNTT	Total Time	37	35.32	5.22
CORRECT	% Correct Engagements	37	49.24	14.44

	TI	TII	TIII	TIV	TV	TVI
TI	1.00000	0.76528	0.71794	0.85781	0.72338	0.51464
TII	0.76528	1.00000	0.69374	0.80961	0.40774	0.45656
TIII	0.71794	0.69374	1.00000	0.88285	0.43109	0.37285
TIV	0.85781	0.80961	0.88285	1.00000	0.53263	0.42154
TV	0.72338	0.40774	0.43109	0.53263	1.00000	0.47511
TVI	0.51464	0.45656	0.37285	0.42154	0.47511	1.00000
GI	0.13304	0.07793	0.15049	0.19175	0.05745	0.18948
GII	0.18962	0.14440	0.19044	0.24292	0.07771	0.22004
GIII	-0.00301	-0.10706	0.16555	0.07605	-0.11384	0.09707
GIV	0.13180	0.01614	0.21845	0.17521	0.00480	0.17139
GV	0.01699	-0.07373	0.15683	0.12887	-0.10305	0.12805
GVI	0.25122	0.08720	0.34547	0.36183	0.15828	0.19740
LI	0.28598	0.33438	-0.00464	0.13983	0.07873	0.11243
LII	0.19010	0.21531	-0.07113	0.06991	-0.17846	-0.00532
LIII	0.16189	0.15498	-0.11654	0.04291	-0.01580	0.02114
LIV	0.14540	0.19713	-0.14945	0.03390	-0.07870	0.07828
LV	0.28161	0.30517	0.02096	0.14421	0.02416	0.09203
LVI	0.22293	0.20306	-0.08057	0.04125	0.03385	0.16866
DI	0.11570	0.06742	0.07313	0.10080	-0.04650	0.30205
DII	0.04917	-0.01511	0.02117	0.05962	-0.16431	0.12052
DIII	-0.05802	-0.06315	-0.14344	-0.11372	-0.22831	0.12852
DIV	0.01094	0.03480	0.00901	-0.02381	-0.14935	0.18406
DV	0.03581	-0.02514	-0.19665	-0.10772	-0.20041	0.15132
DVI	0.01616	-0.13972	-0.07659	-0.12218	-0.14563	0.06897
TRDNMG	0.23490	0.28633	0.24256	0.18162	0.13482	-0.10198
TRDNFR	0.07042	0.05878	0.08320	0.01668	0.01026	-0.10014
TRDNMGH	0.29662	0.31693	0.37714	0.31480	0.15149	-0.16634
TRDNOT	-0.10272	-0.28084	-0.36851	-0.26496	0.13729	0.14202
TRDATT	0.12779	-0.05834	-0.12922	-0.05778	0.20943	0.32595
CORRECT	0.17049	0.12716	0.26480	0.15609	0.12679	-0.05172

	GI	GII	GIII	GIV	GV	GVI
TI	0.13304	0.18962	-0.00301	0.13180	0.01699	0.25122
TII	0.07793	0.14440	-0.10706	0.01514	-0.07373	0.08720
TIII	0.15049	0.19044	0.16565	0.21845	0.15683	0.34647
TIV	0.19175	0.24292	0.07605	0.17521	0.12887	0.36183
TV	0.05745	0.07771	-0.11384	0.03480	-0.10305	0.15828
TVI	0.18948	0.22004	0.09707	0.17139	0.12805	0.19740
GI	1.00000	0.83559	0.56866	0.72612	0.77518	0.71192
GII	0.83559	1.00000	0.59372	0.77742	0.63727	0.64763
GIII	0.56866	0.59372	1.00000	0.85797	0.47993	0.47619
GIV	0.72612	0.77742	0.85797	1.00000	0.52642	0.59738
GV	0.77518	0.63727	0.47993	0.52642	1.00000	0.76212
GVI	0.71192	0.64763	0.47619	0.59738	0.76212	1.00000
LI	0.02313	0.04837	0.01496	0.12837	-0.04316	-0.04046
LII	-0.10934	-0.02877	-0.05542	0.04123	-0.08573	-0.09809
LIII	-0.22999	-0.21063	-0.17010	-0.07840	-0.25747	-0.28545
LIV	-0.21411	-0.11396	-0.11770	-0.03695	-0.22729	-0.22854
LV	-0.03040	-0.11799	-0.20165	-0.09569	-0.06751	-0.19582
LVI	-0.04607	-0.02252	-0.04869	0.13851	-0.08067	-0.07875
DI	0.35787	0.14648	0.10696	0.15918	0.43828	0.49693
DII	0.35852	0.29230	0.28019	0.31368	0.47744	0.51418
DIII	0.19103	0.04210	0.10783	0.10114	0.29010	0.21567
DIV	0.20718	0.04608	0.08843	0.15527	0.30539	0.32512
DV	0.18073	0.05080	0.04259	0.03427	0.24158	0.09606
DVI	0.06013	-0.06367	-0.01599	-0.09575	0.16854	0.01406
TBDNMG	-0.17571	-0.06925	0.17212	0.02182	-0.07590	-0.02059
TBDNFR	0.00284	0.05947	0.29179	0.12479	0.19641	0.17587
TBDNMGH	-0.19295	-0.02257	0.16646	0.05027	-0.07279	0.07051
TBDNOT	-0.06763	-0.20018	-0.29734	-0.23266	0.01006	-0.09996
TBDNTT	-0.01036	0.00818	-0.19206	-0.04556	0.05640	-0.05393
CORRECT	-0.22142	-0.06398	0.15903	0.01477	-0.08069	0.04080

	LI	LII	LIII	LIV	LV	LVI
TI	0.28599	0.19010	0.16189	0.14540	0.28161	0.22293
TII	0.33438	0.21531	0.15498	0.19713	0.30517	0.20996
TIII	-0.00464	-0.07113	-0.11654	-0.14945	0.02096	-0.08067
TIV	0.13983	0.06991	0.04291	0.03390	0.14421	0.04125
TV	0.07873	-0.17846	-0.01580	-0.07870	0.02416	0.03385
TVI	0.11243	-0.00532	0.02114	0.07828	0.09203	0.16866
GI	0.02313	-0.10934	-0.22999	-0.21411	-0.03040	-0.04607
GII	0.04837	-0.02377	-0.21053	-0.11396	-0.11799	-0.02252
GIII	0.01496	-0.05542	-0.17010	-0.11770	-0.20165	-0.04869
GIV	0.12837	0.04123	-0.07840	-0.00695	-0.09569	0.10851
GV	-0.04316	-0.08573	-0.25747	-0.22729	-0.06751	-0.08067
GVI	-0.04046	-0.09809	-0.28545	-0.22854	-0.19582	-0.07875
LI	1.00000	0.83080	0.79394	0.83811	0.51476	0.57103
LII	0.83080	1.00000	0.81528	0.87387	0.54149	0.64002
LIII	0.79394	0.81528	1.00000	0.90647	0.54331	0.59118
LIV	0.83811	0.87387	0.90647	1.00000	0.51680	0.63162
LV	0.51476	0.54149	0.54331	0.51680	1.00000	0.78414
LVI	0.57103	0.64002	0.59118	0.63162	0.78414	1.00000
DI	0.07176	0.12727	-0.01384	0.00329	0.01558	-0.00394
DII	0.13973	0.26716	0.13932	0.17920	-0.02125	0.01990
DIII	0.08099	0.11774	0.07273	-0.01234	0.05222	0.02475
DIV	0.07121	0.09507	0.09213	0.01572	0.01005	0.09515
DV	0.04199	0.16877	0.09109	0.01593	0.22948	0.11138
DVI	-0.14016	0.00841	0.06670	-0.03658	0.01702	-0.05307
TSDNMG	0.13248	0.01266	-0.00315	0.03090	-0.10532	-0.04413
TSDNFR	0.04911	-0.05901	-0.13622	-0.09117	-0.19741	-0.05527
TSDNMGH	0.11265	0.01630	-0.03192	0.00205	-0.13594	-0.09541
TSDNOT	-0.04064	-0.06250	0.03458	0.04594	-0.01303	-0.03608
TSDNTT	0.23538	0.15815	0.14345	0.17554	0.34891	0.27532
CORRECT	0.00968	-0.07831	0.00433	-0.03231	-0.24482	-0.20403

	DI	DII	DIII	DIV	DV	DVI
TI	0.11570	0.04917	-0.05802	0.01094	0.03581	0.01616
TII	0.06742	-0.01511	-0.06315	0.03480	-0.02614	-0.13972
TIII	0.07313	0.02117	-0.14344	0.03901	-0.19665	-0.07669
TIV	0.10080	0.05962	-0.11372	-0.02381	-0.10772	-0.12218
TV	-0.04650	-0.16431	-0.22851	-0.14935	-0.20041	-0.14563
TVI	0.[illegible]0205	0.12052	0.12852	0.18406	0.15132	0.06897
GI	0.35787	0.35852	0.19103	0.20718	0.18073	0.06013
GII	0.14648	0.29230	0.04210	0.04608	0.05080	-0.06367
GIII	0.1[illegible]596	0.28019	0.10783	0.03843	0.04259	-0.01599
GIV	0.15918	0.31368	0.10114	0.15527	0.03427	-0.09575
GV	0.45828	0.47744	0.29010	0.33539	0.24158	0.16854
GVI	0.49693	0.51418	0.21567	0.32512	0.09606	0.01406
LI	0.07176	0.13973	0.08099	0.03121	0.04199	-0.14016
LII	0.12727	0.26716	0.11774	0.09507	0.16877	0.00841
LIII	-0.01384	0.13932	0.07273	0.09213	0.09109	0.06670
LIV	0.00329	0.17920	-0.01234	0.01572	0.01593	-0.03658
LV	0.01558	-0.02125	0.05222	0.01005	0.22948	0.01702
LVI	-0.00394	0.01290	0.02475	0.09515	0.11138	-0.05307
DI	1.00000	0.78055	0.78315	0.79855	0.67551	0.45848
DII	0.78055	1.00000	0.58675	0.69569	0.52411	0.52827
DIII	0.78315	0.58675	1.00000	0.83441	0.78616	0.51897
DIV	0.79855	0.69569	0.83441	1.00000	0.57030	0.58926
DV	0.67551	0.52411	0.78616	0.57030	1.00000	0.54244
DVI	0.45848	0.52827	0.51897	0.58926	0.54244	1.00000
TSDNMG	-0.09592	-0.05058	-0.11932	-0.02378	-0.18000	-0.15164
TSDNFR	0.04717	0.07671	-0.01291	0.08509	-0.09243	-0.04347
TSDNMGH	-0.09654	-0.05732	-0.07246	-0.02612	-0.22799	-0.21319
TSDNOT	0.09196	-0.01285	-0.08788	-0.04144	0.10427	0.08292
TSDNTT	-0.00072	-0.14022	-0.05998	-0.17988	0.10162	-0.11207
CORRECT	-0.03241	-0.03771	-0.00169	0.03066	-0.06163	-0.03706