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Research Report 1635

Interdevice Transfer of Training Between the Guard Unit Armory Device, Full-Crew Interactive Simulation Trainer—Armor and the Mobile Conduct-of-Fire Trainer

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U.S. Army Research Institute

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13. ABSTRACT *(Maximum 200 words)*
To examine interdevice transfer between the Mobile Conduct-of-Fire Trainer (M-COFT) and the Guard Unit Armory Device, Full-Crew Interactive Simulation Trainer--Armor (GUARDFIST I), and the relationship between tank gunnery performance on the two devices, a total of 34 Army National Guard tank crews were assigned to two groups. Group 1 pretested and trained on M-COFT and posttested on GUARDFIST I. Group 2 pretested and trained on GUARDFIST I and posttested on M-COFT. M-COFT training improved the speed and accuracy of GUARDFIST I posttest scores, whereas GUARDFIST I training improved only the speed of M-COFT posttest scores. Performance on the two devices was significantly but moderately related, with higher correlations occurring between more temporally contiguous measures: pretest scores with training measures and training measures with posttest scores. Estimated time requirements for completion of training matrix engagement exercises on each device are provided. The findings suggest that the two devices can be used interchangeably to improve the speed of device-based tank gunnery engagements, but that M-COFT usage should precede GUARDFIST I usage to improve accuracy. Additional research is suggested to examine
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further the issue of GUARDFIST I to M-COFT transfer, especially with regard to gunnery accuracy and transfer to live-fire engagements from the two devices.

Research Report 1635

Interdevice Transfer of Training Between the Guard Unit Armory Device, Full-Crew Interactive Simulation Trainer—Armor and the Mobile Conduct-of-Fire Trainer

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Training Simulation

FOREWORD

The Army National Guard (ARNG) is emphasizing the use of training devices to enhance home-station training of M1 tank gunnery. To this end, work is under way to develop a device-based tank gunnery training and evaluation strategy for ARNG use at the company level. This report describes the results of research performed to determine (a) interdevice transfer of training between the Guard Unit Armory Device, Full-Crew Interactive Simulation Trainer--Armor (GUARDFIST I) and the Mobile Conduct-of-Fire Trainer (M-COFT), and (b) training time requirements for each device.

The research was conducted by the U.S. Army Research Institute Boise Element at Gowen Field, Idaho, whose mission is to improve the effectiveness and efficiency of Reserve Component (RC) training by using the latest in training technology. The research task supporting this mission, "Application of Technology to Meet RC Training Needs," is organized under the "Training for Combat Effectiveness" program area.

The National Guard Bureau (NGB) sponsored this research under a memorandum of understanding signed 12 June 1985. Results have been presented to Chief, Organization and Training Division, Training Support and Management Branch, NGB; Chief, Training Division, Office of the Chief, Army Reserve; Director, Training Development and Analysis Directorate, Training and Doctrine Command; and Director, Directorate of Training Development, U.S. Army Armor School.

EDGAR M. JOHNSON
Acting Director

INTERDEVICE TRANSFER OF TRAINING BETWEEN THE GUARD UNIT ARMORY DEVICE, FULL-CREW INTERACTIVE SIMULATION TRAINER--ARMOR AND THE MOBILE CONDUCT-OF-FIRE TRAINER

EXECUTIVE SUMMARY

Requirement:

This research was performed to (a) test for transfer of tank gunnery training between M-COFT and GUARDFIST I (hereafter referred to as COFT and GUARDFIST), (b) examine the relationship between COFT and GUARDFIST gunnery performance, and (c) determine training time requirements for each device.

Procedure:

Thirty-four tank crews from four Army National Guard armor companies were assigned to one of two gunnery training groups. Group 1 received a COFT pretest, trained on a modified COFT training matrix, and received a GUARDFIST posttest. For Group 2 the sequence was reversed: GUARDFIST pretest, GUARDFIST training, and COFT posttest.

Findings:

COFT training improved the speed and accuracy of GUARDFIST test performance, whereas GUARDFIST training only improved the speed of COFT test performance. Performance on the two devices was significantly but moderately related, with stronger correlations occurring between more temporally contiguous measures: pretest scores with training measures and training measures with posttest scores. Estimates were derived for the amount of time required to complete the matrix-related engagement exercises on the two devices.

Utilization of Findings:

The findings suggest that COFT and GUARDFIST can be used interchangeably to improve the speed of device-based tank gunnery engagements, whereas COFT should be used for improving their accuracy. If both devices are used for training, the more effective/efficient usage sequence would be COFT first, then GUARDFIST, at least for the engagement conditions found to be in

common in the training matrices of the two devices. The training time estimates can be used to support efficient scheduling of gunnery training on the two devices. Additional research is needed to look at the possibility of GUARDFIST to COFT transfer in terms of gunnery accuracy and to determine the transfer to live-fire performance that can be expected from training on each device, both individually and in combination.

INTERDEVICE TRANSFER OF TRAINING BETWEEN THE GUARD UNIT ARMORY DEVICE, FULL-CREW INTERACTIVE SIMULATION TRAINER--ARMOR AND THE MOBILE CONDUCT-OF-FIRE TRAINER

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NOTICES

INTERDEVICE TRANSFER OF TRAINING BETWEEN THE GUARD UNIT ARMORY DEVICE, FULL-CREW INTERACTIVE SIMULATION TRAINER--ARMOR AND THE MOBILE CONDUCT-OF-FIRE TRAINER

Background

Total Force Policy requires that the Army's Reserve Component (RC) soldiers attain and maintain readiness standards comparable to those of their Active Component counterparts. Because of constraints on time and access to range/maneuver areas, the majority of RC training must be accomplished at home station (i.e., armory or reserve center), where it is difficult to provide the kind of realistic tank gunnery training necessary to ensure skill proficiency.

Tank Gunnery Simulation

To increase RC home-station training capability (especially for combat arms units), the National Guard Bureau is seeking to use technology in the form of simulators and training devices. In the armor arena, for example, such devices include M-COFT and GUARDFIST I (hereafter referred to as COFT and GUARDFIST, respectively) for the training of tank gunnery. (See Appendix A for descriptions of the physical and instructional features of each device.)

To guide the use of this technology and thereby promote the successful RC transition from equipment-based to device-based training in the area of tank gunnery, Morrison, Campshure, and Doyle (1991) developed a strategy to link device-based training with on-tank training and evaluation. Under this strategy, the purpose of device-based training is to prepare individuals, crews, and platoons to be trained on the tank combat tables, with these tables providing the intermediate and terminal performance objectives for gunnery training.

The strategy has three phases: (a) begin with basic device-based training at the armory, (b) proceed to intermediate device-based training at home station, coupled with on-tank training at the Local Training Area (LTA), and (c) conclude with live-fire tank combat table evaluation at the Major Training Area (MTA). For each phase, the strategy suggests an interdevice training and testing sequence with associated training time allocation and criterion performance estimates for each device and recommends how to train best with each device to promote effective/efficient learning, retention, and transfer.

Although the training strategy is comprehensive, it must be regarded as only interim or draft because its recommendations in a number of areas are based on untested suppositions. One such area involves the extensive use of both GUARDFIST and COFT during

Phases 1 and 2. While past research has shown COFT training to be effective (Morrison, Drucker, & Campshure, 1991), little is known about the benefits of GUARDFIST training. It is not known, for example, how training on GUARDFIST influences (i.e., transfers to) performance on COFT, and vice versa. Also, it is unknown whether performance on GUARDFIST is an accurate indicator of performance on COFT, and vice versa. If prior training on GUARDFIST (or COFT) facilitates subsequent performance on COFT (or GUARDFIST), i.e. positive transfer, and performance on one device is indicative of performance on the other, current interim strategy recommendations could be revised to allow for the interchangeability of the two devices for similar training engagement exercises and a reduction in the amount of training suggested for each device.

A second area of uncertainty involves training time recommendations provided by the interim strategy for completion of specific training phases on each device. Currently, the strategy calls for 13 2-hr sessions of COFT training and 10 1-hr sessions of GUARDFIST training per crew across Phases 1 and 2. These recommendations, however, lack empirical underpinnings and may be excessive because they refer to initial training. In contrast, the majority of RC soldiers have completed initial training on most tank gunnery skills and are in need of sustainment rather than initial training, with the former usually requiring less time to complete than the latter (Schendel & Hagman, 1991). In addition, current training time estimates do not take into account the probability of reduced training time needs as a result of positive interdevice transfer.

Thus, to ensure the development of an effective and efficient device-based training strategy for use at the RC unit level, additional information is needed on transfer of training effects between COFT and GUARDFIST, and the accuracy of device-based training time estimates.

Purpose

This research (a) tested for transfer of training effects between COFT and GUARDFIST, (b) examined correlations between test scores on the two devices, and (c) compared estimated and actual device-based training times.

Questions to be Answered

1. To what extent does prior training on COFT improve subsequent performance on GUARDFIST (and vice versa)?

2. To what extent is performance on the two devices correlated?

3. To what extent does the addition of demographic information improve the accuracy of predicting interdevice transfer?

4. Are current device-based training time estimates accurate?

Method

Participants

Thirty-four tank crews from the 2nd Battalion, 116th Armor Brigade of the Idaho Army National Guard served as participants. All tank commanders (TCs) and gunners were experienced tankers, with approximately 2 hr of prior experience on COFT and 2 hr of prior experience on GUARDFIST. Only intact crews (defined as no TC or gunner crew changes between pretest and posttest) were retained for data analysis.

Design and Procedure for Testing Transfer of Training

Tank crews were randomly assigned by company to one of two treatment groups, as shown in Figure 1. Group 1 received a COFT pretest (described below) and then began working through a modified COFT training matrix that included specific exercises pertaining to anticipated Table VIII engagement conditions (see Appendix B). After training, Group 1 received a GUARDFIST posttest (described below). For Group 2, the sequence was reversed: GUARDFIST pretest, GUARDFIST training with a training and evaluation matrix modified to include specific exercises pertaining to anticipated Table VIII engagement conditions (see Appendix C), and COFT posttest. Training began immediately following completion of pretests. Posttests occurred from 1 to 3 months following completion of training. Maneuver training occurred during the interval between device training and posttesting. All training and testing was conducted by in-unit GUARDFIST and COFT instructor operators under researcher supervision.

GROUP	*n* OF CREWS	PRETEST	3 MONTHS OF TRAINING	POSTTEST
1	19	COFT	COFT	GUARDFIST
2	15	GUARDFIST	GUARDFIST	COFT

Figure 1. Treatment design.

With this design, the hypothesis of transfer of training between the two devices could receive support in four ways. If COFT training transfers to GUARDFIST, then GUARDFIST posttest scores for Group 1 should exceed GUARDFIST pretest scores for Group 2. Conversely, if GUARDFIST training transfers to COFT, then COFT posttest scores for Group 2 should exceed COFT pretest scores for Group 1. Bidirectional transfer of training would be demonstrated if both the above conditions were met, whereas either one of the above conditions in isolation would constitute evidence for unidirectional transfer.

A second way to support the transfer of training hypothesis would be to demonstrate that training measures on one device (e.g., amount of training matrix advancement) correlate with subsequent test scores on the other device. A third test of transfer would be the correlation between test scores on the two devices. This is not a strict test of transfer, because correlation does not necessarily mean that training on one device improves scores on the other. Nevertheless, it is reasonable to expect that if transfer is to occur, then scores on the two devices should correlate.

Finally, transfer of training may depend on other variables such as age, rank, or amount of tank gunnery experience. For this reason, the predictability of COFT scores were examined by combining these variables with GUARDFIST scores, and the predictability of GUARDFIST scores were examined by combining these measures with COFT scores.

COFT and GUARDFIST Tests

The COFT test consisted of exercises 346311 and 346111 selected from the current COFT TC/gunner training matrix (Department of the Army, 1988; General Electric, 1989), designed to cover a variety of engagement conditions practiced during GUARDFIST training. As shown in Figure 2, testing conditions included day and night engagements requiring the use of the Gunner's Primary Sight (GPS), Gunner's Auxiliary Sight (GAS), and Thermal Imaging Sight (TIS), both full-crew and 3-man (gunner missing) conditions, nuclear, biological, and chemical (NBC) conditions, and both a stationary and moving tank firing at a total of 20 stationary and moving targets ranging from 920-2080m with most (90%) occurring at distances between 1530-2080m.

The GUARDFIST test was designed to include a variety of engagement conditions practiced during COFT training. As shown in Figure 3, one task was included from each of five group/exercise combinations taken from the current GUARDFIST training and evaluation matrix (Department of the Army, 1990). Across tasks, testing conditions were varied to include day and night engagements requiring use of the GPS, GAS, and TIS, both full-crew and 3-man (gunner missing) conditions, NBC conditions, and both a stationary and moving tank firing at a total of nine stationary and moving targets ranging from 800-2000m.

Both the COFT and GUARDFIST tests were scored according to criteria developed by Hoffman and Witmer (1989) to produce Fire Rate, Hit Proportion, and Hit Rate scores. Hit Rate is an aggregate measure of gunnery proficiency weighted for the number

ENGAGEMENT CONDITIONS

Exercise	Sequence	Sight	Tank	Target	Range(m)	TC-only	NBC
34631	1	GPS	M	S (tank)	1730	No	No
		GPS	M	M (tank)	1810	No	No
	2	GPS	M	S (tank)	1680	No	No
		GPS	M	M (chopper)	2080	No	No
	3	TIS	M	S (tank)	1700	No	No
		TIS	M	S (troops)	920	No	No
	4	GPS	M	S (tank)	1730	No	No
		GPS	M	S (chopper)	1780	No	No
	5	TIS	M	M (tank)	1530	No	No
		TIS	M	M (APC)	1620	No	No
34611	1	GPS	S	S (tank)	2070	No	Yes
		GPS	S	S (troops)	1060	No	Yes
	2	GPS	S	S (tank)	1650	Yes	No
		GPS	S	S (tank)	1670	Yes	No
		GPS	S	S (tank)	1900	Yes	No
	3	GPS	S	S (tank)	1730	No	No
		GPS	S	S (tank)	1980	No	No
		GPS	S	M (tank)	2000	No	No
	4	GAS	S	M (tank)	1830	No	No
		GAS	S	M (chopper)	1880	No	No

Figure 2. COFT test engagement conditions. (S = Stationary, M = Moving)

ENGAGEMENT CONDITIONS

Group/Ex	Task	Sight	Tank	Target	Range(m)	3-man	NBC
4/6	1	TIS	M	M (tank)	1400-1600	No	No
			M	S (tank)			
5/3	1	GPS	M	S (tank)	1900-2000	No	No
4/3	1	GAS	S	M (tank)	800-1000	No	No
			S	S (ZSU)			
2/3	1	TIS	S	S (2-tanks)	900-1700	Yes	No
6/3	1	GPS	M	S (tank)	800-1000	No	Yes
			M	S (troops)			

Figure 3. GUARDFIST test engagement conditions. (S = Stationary, M = Moving)

of targets in each engagement. Hoffman and Witmer (1989) define Hit Rate as:

Hit Rate	=	Hit Proportion	x	Fire Rate
(hits/time)		(hits/rounds)		(rounds/time)

Thus, "Hit rate ... is the recommended metric for assessment of overall crew proficiency .... Hit rate is calculated from the weighted averages for firing rate and hit probability, where engagement firing rates and hit probabilities are weighted by the number of targets in the engagement" (see Hoffman and Witmer, 1989 for details). Although the scoring procedure for Hit Rate is computationally complex and laborious, it includes in a single metric the essential elements of gunnery success: rounds fired, time expended, accuracy of fire, and completeness (were all threat targets hit?), and can be captured from performance printouts provided by both COFT and GUARDFIST.

Other measures also were examined, including the number of device-passes ("GOs") on the GUARDFIST test and proportion of targets fired on during the COFT test. Proportion of targets fired on was defined as the number of different targets fired on divided by the total number of available targets.

Training Sessions

The COFT training matrix is divided into exercises, each comprising multiple engagements (typically 4 or 5). Each engagement features multiple targets (from 1 to 3). Engagements are combined within exercises to yield a total of 10 targets. In contrast, the GUARDFIST training matrix is divided into group/exercise tasks, which are individual engagements comprising multiple targets (usually 2). Thus, a basic training unit (an exercise with COFT and a task with GUARDFIST) is different for the two devices. COFT training exercises typically comprise from 4 to 5 times as many targets as a GUARDFIST task. For sake of continuity, "exercise" is used throughout to refer to the basic training unit of both device matrices. The reader, however, should keep the nonequivalence in mind.

Each crew was scheduled for one training session at their local armory during three consecutive inactive duty training weekends (October, November, December). Amount of training time that each crew received during each session was allowed to vary under the assumption that amount of training and extent of matrix advancement could be used as variables to predict subsequent test scores on the alternate device.

Prior to training, crews were informed that both speed and accuracy would be evaluated. Feedback was not provided during testing but was provided during training to promote learning. Crews were encouraged to advance as far as possible into the modified training matrix, but could proceed to the next training unit only when they received a "GO" from the training device. A "NO GO" resulted in a repeat of the same exercise. Crews could repeat an exercise as often as necessary to achieve a "GO."

Five training measures were collected: (a) matrix advancement (maximum advancement into the training matrix: For the modified COFT training matrix, this was the number of successfully completed exercises. For the GUARDFIST matrix, advancement was determined by combining all available training and evaluation exercises in the unmodified matrix and counting consecutively to the point of maximum advancement.), (b) attempted exercises (the sum of all exercises attempted: "GOs" plus "NO GOs"), (c) trial efficiency (completed exercises divided by the total number of attempted exercises), (d) training time (total combined training time in minutes across all training sessions), and (e) time efficiency (completed exercises divided by total training time in minutes).

Demographics

As part of the pretest, information was collected from TCs and gunners on age, amount of tank gunnery experience, rank, and visual acuity (see Appendix D). Thirteen dimensions of tank gunnery experience were measured on a scale of 1 to 5, with higher numbers indicating more experience. Rank was coded numerically for enlisted and noncommissioned officers as follows: E4 = 4; E5 = 5; E6 = 6; E7 = 7. Commissioned officers were coded as follows: Second Lieutenant = 10; First Lieutenant = 11; Captain = 12. Vision was coded as 1 = perfect vision without glasses or contacts; 2 = vision corrected by either glasses or contacts. Seven TCs and 5 gunners did not return their questionnaires.

Results

The Effect of Prior Training

Data in Table 1 support the hypothesis of unidirectional transfer of training (from COFT to GUARDFIST), but do not support the bidirectional transfer of training hypothesis. GUARDFIST posttest scores for Group 1 (which trained on COFT before taking the GUARDFIST posttest) were significantly higher than GUARDFIST pretest scores for Group 2 (which took the GUARDFIST pretest without prior COFT training), as revealed by a MANOVA for the four GUARDFIST variables, $\underline{F}(4, 29) = 7.16$, $\underline{p} < .001$. Univariate ANOVAS indicated that GUARDFIST Fire Rate, Hit Rate, and the number of GUARDFIST test engagements receiving a device-assigned "GO" differed significantly, while GUARDFIST Hit Proportion scores approached significance.

Table 1

GUARDFIST and COFT Mean Test Scores For the Two Training Groups, Expressed in Hoffman and Witmer (1989) Units of Measurement

Variable	Group 1 (n = 19)	Group 2 (n = 15)	Univariate ANOVAS $F(1,32)$	p
Transfer from COFT training to GUARDFIST[a]				
GUARDFIST Fire Rate	.045 --->	.023	17.1	.001
GUARDFIST Hit Proportion	.039	.234	3.7	.062
GUARDFIST Hit Rate	.018 --->	.008	9.8	.004
GUARDFIST Test "Go's"	1.00 --->	.07	11.2	.002
Transfer from GUARDFIST training to COFT[b]				
COFT Fire Rate: Exercise 1	.060	.067		
COFT Hit Proportion: Exercise 1	.547	.418		
COFT Hit Rate: Exercise 1	.035	.030		
COFT Fire Rate: Exercise 2	.035	.040		
COFT Hit Proportion: Exercise 2	.443	.489		
COFT Hit Rate: Exercise 2	.016	.019		
COFT Fire Rate: Total Test	.048	.050		
COFT Hit Proportion: Total Test	.489	.455		
COFT Hit Rate: Total Test	.025	.023		

Note. Group 1 sequence:
COFT Pretest > COFT Training > GUARDFIST Posttest
Group 2 sequence:
GUARDFIST Pretest > GUARDFIST Training > COFT Posttest

[a]Transfer from COFT training to GUARDFIST occurred when Group 1 GUARDFIST scores exceeded Group 2 GUARDFIST scores.

[b]Transfer from GUARDFIST training to COFT would have occurred if Group 2 COFT scores had exceeded Group 1 COFT scores.

[c]Arrows indicate significant group differences.

Transfer of training in the other direction, from GUARDFIST to COFT, was examined with a series of MANOVAS. A MANOVA based on all 9 COFT variables was not significant, $F(9, 24) = 1.39$, $p > .05$. Because of the relatively small N and large error degrees of freedom associated with testing all 9 variables simultaneously, three other MANOVAS were conducted, based on COFT Exercise 1, Exercise 2, and combined exercises. No significant differences occurred between the two groups in any of the analyses (each with df = 3, 33), with F ratios of 1.66, <1, and <1, respectively, for Exercise 1, Exercise 2, and both combined.

Although the pattern of GUARDFIST group differences suggests unidirectional transfer from COFT to GUARDFIST, a competing alternative explanation is that despite random assignment procedures Group 1 crews were superior to crews in Group 2 prior to any testing or training, enabling them to score as high on COFT prior to any training as Group 2 scored after GUARDFIST training. This potential alternative explanation cannot be ruled out a priori because random assignment to treatment groups was necessarily accomplished at the company level, rather than at the preferable level of individual tank crews. This alternative explanation, however, is not supported by demographic differences between the two groups or by past differences in gunnery performance.

Gunners from the two groups were comparable on all measures (see Table 2), and the only significant TC difference (see Table 3) was in the direction opposite to what would be expected if the alternative explanation were correct. TCs from Group 2 were significantly more experienced in target acquisition and/or situation evaluation. Group 2 TCs were more experienced at main gun offensive precision gunnery at a level that approached statistical significance.

Table 2

Gunner Demographics and Tank Gunnery Experience for the Two Training Groups

Variable	Group 1 (*n* = 16)	Group 2 (*n* = 13)	*F*(1,27)
Rank	5.2	5.3	<1
Age	30.2	30.5	<1
Vision	1.7	1.5	<1
Gunnery Experience:			
Perform prepare-to-fire checks	3.3	3.2	<1
Day search with closed hatch	3.3	3.2	<1
Night search	3.4	3.2	<1
Detect/locate/identify targets	3.6	3.3	<1
Offensive precision gunnery	3.5	3.3	<1
Defensive precision gunnery	3.6	3.2	<1
Engage single target with coax	3.0	2.8	<1
Use re-engage technique	2.9	2.8	<1
Engage multiple targets	3.3	3.3	<1
Emergency degraded mode engagements	2.5	2.3	<1
Engagements from gunner's position	3.5	3.8	<1
Acquire targets/ evaluate sit.	3.3	3.1	<1

Table 3

Tank Commander Demographics and Tank Gunnery Experience for the Two Training Groups

Variable	Group 1 (*n* = 14)	Group 2 (*n* = 13)	*F*(1,25)	*p*
Rank	7.9	6.8	1.1	ns
Age	32.1	35.3	1.0	ns
Vision	1.4	1.5	<1	-
Gunnery Experience:				
Perform prepare-to-fire checks	3.6	4.1	1.3	ns
Day search with closed hatch	3.9	3.3	1.8	ns
Night search	3.6	4.1	1.5	ns
Detect/locate/identify targets	3.7	4.2	1.7	ns
Offensive precision gunnery	3.5	4.3	3.1	.094
Defensive precision gunnery	3.9	4.2	<1	-
Engage single target with coax	3.3	3.5	<1	-
Use re-engage technique	3.9	3.6	<1	-
Engage multiple targets	3.9	4.0	<1	-
Emergency degraded mode engagements	2.9	2.7	<1	-
Engagements from gunner's position	3.1	3.0	<1	-
Acquire targets/evaluate situation	3.8	<-- 4.5	4.4	.046

[a]Arrows indicate significant group differences.

An examination of the most recently available Table VIII scores (collected during annual training some 5 to 6 months earlier) indicated no difference in gunnery performance between the two groups, $F(1, 13) < 1$. However, scores were available on less than half of the crews.

<u>The Relationship Between Training Measures and Posttest Scores</u>

<u>COFT training followed by GUARDFIST posttest</u>. For Group 1, Matrix Advancement correlated with subsequent GUARDFIST Fire Rate and Hit Rate at a level approaching statistical significance (see Table 4).

<u>GUARDFIST training followed by COFT posttest</u>. For Group 2, a more complex pattern of relationships occurred between GUARDFIST training measures and COFT posttest scores (see Table 5). Matrix Advancement was related to Fire Rate (on Exercise 1 and for both exercises combined) at a level that approached statistical significance. Matrix Advancement was significantly correlated with Proportion of Targets Fired On. The efficiency

Table 4

Correlations Between COFT Training Variables and GUARDFIST Posttest Scores (Group 1; n = 19; COFT Training Followed by GUARDFIST Posttest)

	Group 1 COFT Training Variables				
GUARDFIST Test Scores	Matrix Advancement	Attempted Exercises	Trial Efficiency	Training Time	Time Efficiency
Fire Rate	.35*	.23	.17	.13	.18
Hit Proportion	.15	.18	.00	.23	.04
Hit Rate	.32*	.24	.14	.23	.15
Test "GOs"	.17	-.15	-.03	-.27	.03

* $p < .10$

Table 5

Correlations Between GUARDFIST Training Variables and COFT Posttest Scores (Group 2; n = 15; GUARDFIST Training Followed by COFT Posttest)

	Group 2 GUARDFIST Training Variables				
COFT Test Scores	Matrix Advancement	Attempted Exercises	Trial Efficiency	Training Time	Time Efficiency
Fire Rate: Ex 1	.35*	-.01	.35*	-.23	.17
Fire Rate: Ex 2	.02	.10	.21	-.45**	.45**
Total Fire Rate	.42*	.24	.27	-.28	.31
Hit Prop.: Ex 1	.19	.11	.48**	-.22	.20
Hit Prop.: Ex 2	-.02	-.06	.17	-.22	.08
Total Hit Prop.	.07	.00	.37**	-.26	.15
Hit Rate: Ex 1	.28	.11	.48**	-.20	.19
Hit Rate: Ex 2	.13	.13	.08	-.29	.16
Total Hit Rate	.26	.12	.40*	-.28	.23
Prop. Fired On	.58**	.33	.53**	-.26	.48**

*$p < .10$ **$p < .05$

of advancement through the GUARDFIST training matrix (defined as trial efficiency: the number of exercises successfully completed divided by total number of exercises attempted) significantly predicted several subsequent COFT posttest scores. Efficient crews obtained significantly higher Hit Proportions on Exercise 1 and on both exercises combined, significantly higher Hit Rates on Exercise 1 and fired on a greater proportion of targets. Crews expending less overall training time scored higher on Exercise 2 Fire Rate. Time Efficiency (defined as the number of successfully completed tasks divided by total training time in minutes) was correlated significantly with Fire Rate from Exercise 2 and with overall Proportion of Targets Fired On.

The GUARDFIST training matrix begins with exclusively defensive (stationary tank) engagements. Offensive (moving tank) engagements start with the fifty-first exercise, and become more frequent as crews advance further into the matrix. Some crews in training Group 2 never advanced far enough into the GUARDFIST matrix to reach offensive engagements. Some crews advanced far enough to begin practicing them, and others advanced far enough into the matrix to complete multiple offensive engagements. Because proficiency with offensive engagements is critical for success on the COFT test (see Figure 2), it is reasonable to expect that only crews advancing far enough to complete multiple offensive engagements would exhibit positive transfer to the COFT posttest. Table 6 groups crews into quintiles based on matrix advancement. Only the top quintile advanced sufficiently into the GUARDFIST training matrix to complete multiple offensive training engagements (a mean of 3.3).

Table 6

GUARDFIST Training Matrix Advancement, Mean GUARDFIST Offensive Training Engagements, and Mean COFT Fire Rate and Hit Rate, by Quintile

Quintile	Mean Matrix Advancement	Mean Offensive Engagements	COFT Fire Rate	COFT Hit Rate
1	89	3.3	.066	.033
2	70	1.3	.041	.012
3	47	0.7	.043	.021
4	40	0.0	.048	.034
5	26	0.0	.051	.015

To test for differential transfer of training on the COFT posttest as a function of amount of exposure to offensive

GUARDFIST training engagements, ANOVAS were used to compare COFT Fire Rate and Hit Rate scores of different quintiles. A test between the first quintile and the others combined yielded a significant result on Fire Rate, $F(1, 13) = 11.82$; $p = .004$ (means of .066 and .046 for the first quintile and others combined, respectively), and a nonsignificant difference on Hit Rate, $F = 2.71$, $p > .05$ (means of .033 and .021 for first quintile and others combined, respectively).

Additional tests were run to determine if the significantly different posttest COFT Fire Rate scores might be attributable to either differing amounts of training or to different beginning levels of gunnery proficiency, rather than number of offensive training engagements. Two partial regression analyses were conducted. The first analysis, summarized in the top half of Table 7, tested the incremental contribution of the GUARDFIST pretest (step 3 in the analysis) when added to a prediction equation based upon amount of training time and amount of exposure to GUARDFIST training engagements (steps 1 and 2).

Table 7

Incremental Contributions of GUARDFIST Pretest Fire Rate and Training Variables on Predictions of COFT Posttest Fire Rate (Group 2; $n = 15$)

Entry Order	R^2 Change	F Change	p Change	F Overall	p Overall
Incremental contribution of GUARDFIST pretest					
1. Exposure	.476	11.82	.004	11.82	.004
2. Training Time	.138	4.28	.061	9.54	.003
3. Pretest	.076	2.70	.129	8.16	.004
Incremental contribution of training variables					
1. Pretest	.167	2.60	.131	2.60	.131
2. Training Time	.039	< 1	.460	1.55	.252
3. Exposure	.484	17.19	.002	8.16	.004

Note. Part correlations are equal to the square root of R^2 change values.

Exposure to offensive training engagements was a significant predictor of COFT Fire Rate. In steps 2 and 3 of the analysis, neither training time nor GUARDFIST pretest produced significant increases in R^2 change. The bottom half of Table 7 summarizes the test for incremental contribution of the two training variables (training time and amount of exposure to offensive training engagements; steps 2 and 3), when GUARDFIST pretest is entered first (step 1). GUARDFIST pretest was not a significant predictor. Addition of training time to the equation produced little R^2 change. Addition of the offensive training engagement variable, however, produced a significant R^2 change and boosted the overall F to a level of statistical significance.

These results suggest that transfer of training did occur from GUARDFIST to COFT, but only for crews that received sufficient GUARDFIST-based training on offensive engagements. This transfer, however, occurred only for performance measures involving the speed of engagements (Fire Rate) and not those incorporating an accuracy component (Hit Rate).

To pinpoint the amount of variance in COFT Fire Rate Scores attributable to Matrix Advancement, number of offensive training engagements and Training Time, these variables were entered into a multiple regression algorithm as predictors. Because Matrix Advancement and number of offensive training engagements were correlated, $r(15) = .73$, $p = .001$, only Matrix Advancement entered into the prediction equation. Based on two predictors, the resulting Multiple R was .62, $F(2, 12) = 3.77$, $p = .05$, indicating that 39% of COFT Fire Rate variance could be explained by the two variables. Figure 4 graphically depicts the relationship between observed and predicted COFT Fire Rate scores. The same combination of predictor variables (GUARDFIST Matrix Advancement and Training Time) accounted for 22% of COFT Hit Rate score variance, $R = .47$, $F(2, 12) = 1.71$, $p > .05$. As indicated in Table 5, Matrix Advancement correlated positively with COFT posttest measures and Training Time correlated negatively. Crews with the best COFT scores were those that advanced further into the GUARDFIST training matrix in less time (i.e., they trained efficiently, with few "NO GO" training outcomes relative to "GO" outcomes).

The ability of training measures (Matrix Advancement in both training groups and Trial Efficiency and number of offensive training engagements in Group 2) to predict posttest scores raises the question of whether training performance can be predicted from the pretests that were administered prior to training. Tables 8 and 9 summarize the relationships between pretest COFT scores and COFT training measures for Group 1, and pretest GUARDFIST scores and GUARDFIST training measures for Group 2.

In Group 1, pretest overall Fire Rate was significantly related to Matrix Advancement, $r(19) = .49$, $p = .016$, Trial Efficiency, $r(19) = .55$, $p = .007$, and Time Efficiency, $r(19) = .61$, $p = .003$. Pretest overall Hit Rate also predicted Matrix Advancement, $r(19) = .42$, $p = .035$, and Time Efficiency, $r(19) = .40$, $p = .047$. In Group 2, pretest Fire Rate predicted Trial

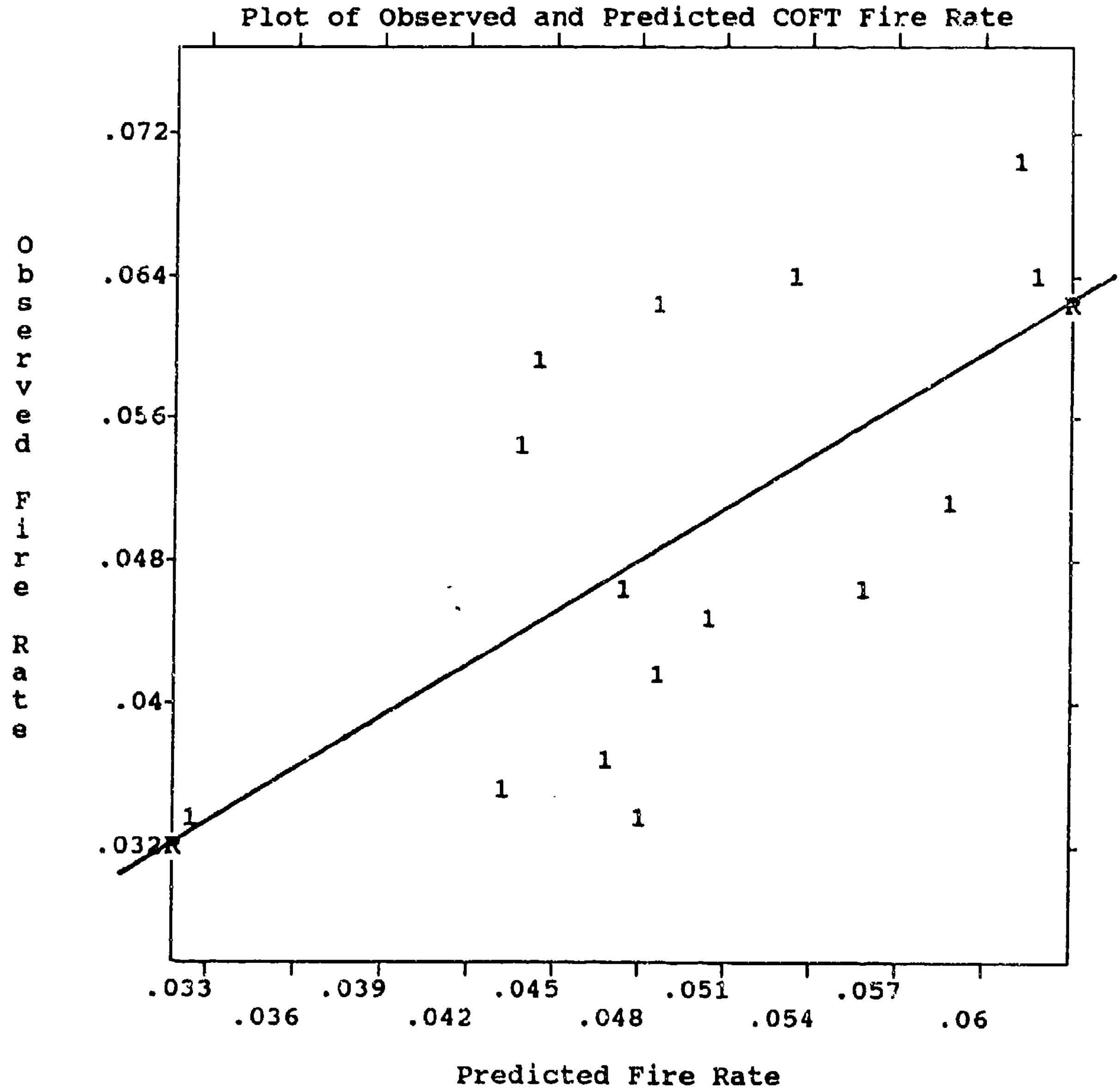

Figure 4. Plot of observed and predicted COFT fire rate for group 2 (*n* = 15, *r* = .62, *p* = .014). Predicted fire rate = .052156 + .0003121323 (matrix advancement) - .000120070 (training time).

Table 8

Correlations Between COFT Pretest Scores and COFT Training Variables for Group 1 (n = 19; COFT Pretest Followed by COFT Training Variables for Group 2 (n = 15; GUARDFIST Pretest)

	Training Variables				
COFT Pretest	Matrix Advancement	Attempted Exercises	Trial Efficiency	Training Time	Time Efficiency
Fire Rate: Ex 1	.54**	.32	.41**	.04	.49**
Fire Rate: Ex 2	.26	-.06	.56***	-.30	[illegible]***
Total Fire Rate	.49**	.19	.55***	-.13	[illegible]***
Hit Prop.: Ex 1	-.03	-.09	-.04	-.25	.03
Hit Prop.: Ex 2	.21	.27	.00	.15	.06
Total Hit Prop.	.12	.09	.00	-.09	.07
Hit Rate: Ex 1	.38*	.30	.10	.05	.19
Hit Rate: Ex 2	.31	.14	.30	-.09	.35*
Total Hit Rate	.42**	.23	.31	-.09	.40**
Prop. Fired On	.48**	.17	.52**	-.16	.60***

*p < .10 **p < .05 ***p < .01

Table 9

Correlations Between GUARDFIST Pretest Scores and GUARDFIST Training Variables for Group 2 (n = 15; GUARDFIST Pretest Followed by GUARDFIST Training Followed by COFT Posttest)

	Training Variables				
GUARDFIST Pretest Scores	Matrix Advance-ment	Attempted Exer-cises	Trial Effi-ciency	Training Time	Time Effi-ciency
Fire Rate	.15	-.20	.86***	-.21	.45**
Hit Proportion	.21	-.09	.62***	-.11	.41*
Hit Rate	.11	-.17	.70***	-.25	.50**
Test "Go's"	.48**	.59***	-.09	.07	.21

*p < .10 **p < .05 ***p < .01

Efficiency, $r(15) = .86$, $p = .001$, and Time Efficiency, $r(15) = .45$, $p = .048$. Hit Rate predicted Trial Efficiency, $r(15) = .70$, *p* = .002, and Time Efficiency, *r*(15) = .50, *p* = .028. Training time, per se, was not related to pretest scores in either training group, although the coefficients tended to be negative, especially for Group 2.

Device Intercorrelation

As an overall test of the intercorrelation of COFT and GUARDFIST scores, data were combined from both groups. The results are summarized in Table 10. Hit Rates from the COFT and GUARDFIST tests were significantly correlated, *r*(34) = .29, *p* = .049. GUARDFIST Fire Rate was consistently related to COFT measures, and was the best single predictor of COFT composite Hit Rate, *r*(34) = .37, *p* = .016.

Table 10

Intercorrelations Between COFT and GUARDFIST Scores (*N* = 34)

	GUARDFIST Measures		
COFT Measures	Fire Rate	Hit Prop	Hit Rate
COFT Fire Rate Exercise 1	.14	.06	.15
COFT Fire Rate Exercise 2	.18	-.01	.11
COFT Fire Rate Total Test	.26*	.07	.21
COFT Hit Proportion Exercise 1	.34**	.14	.26*
COFT Hit Proportion Exercise 2	.20	.01	.08
COFT Hit Proportion Total Test	.34**	.10	.22
COFT Hit Rate Exercise 1	.32**	.15	.29**
COFT Hit Rate Exercise 2	.20	-.01	.10
COFT Hit Rate Total Test	.37**	.13	.29**

*p < .10 **p < .05

Predicting COFT Hit Rate From GUARDFIST Test Scores and Crew Demographics

For combined groups, a combination of three predictor variables (gunner's rank, TC rank, and GUARDFIST Fire Rate) successfully modelled COFT Hit Rate, *R* = .52, *F*(3, 30) = 3.72, *p* = .022. Betas for all three predictors were positive, indicating that crews with higher ranking gunners and commanders and higher GUARDFIST Fire Rate scores also obtained higher COFT Hit Rate scores. Figure 5 graphically depicts the relationship between obtained and predicted COFT Hit Rate scores. (Missing

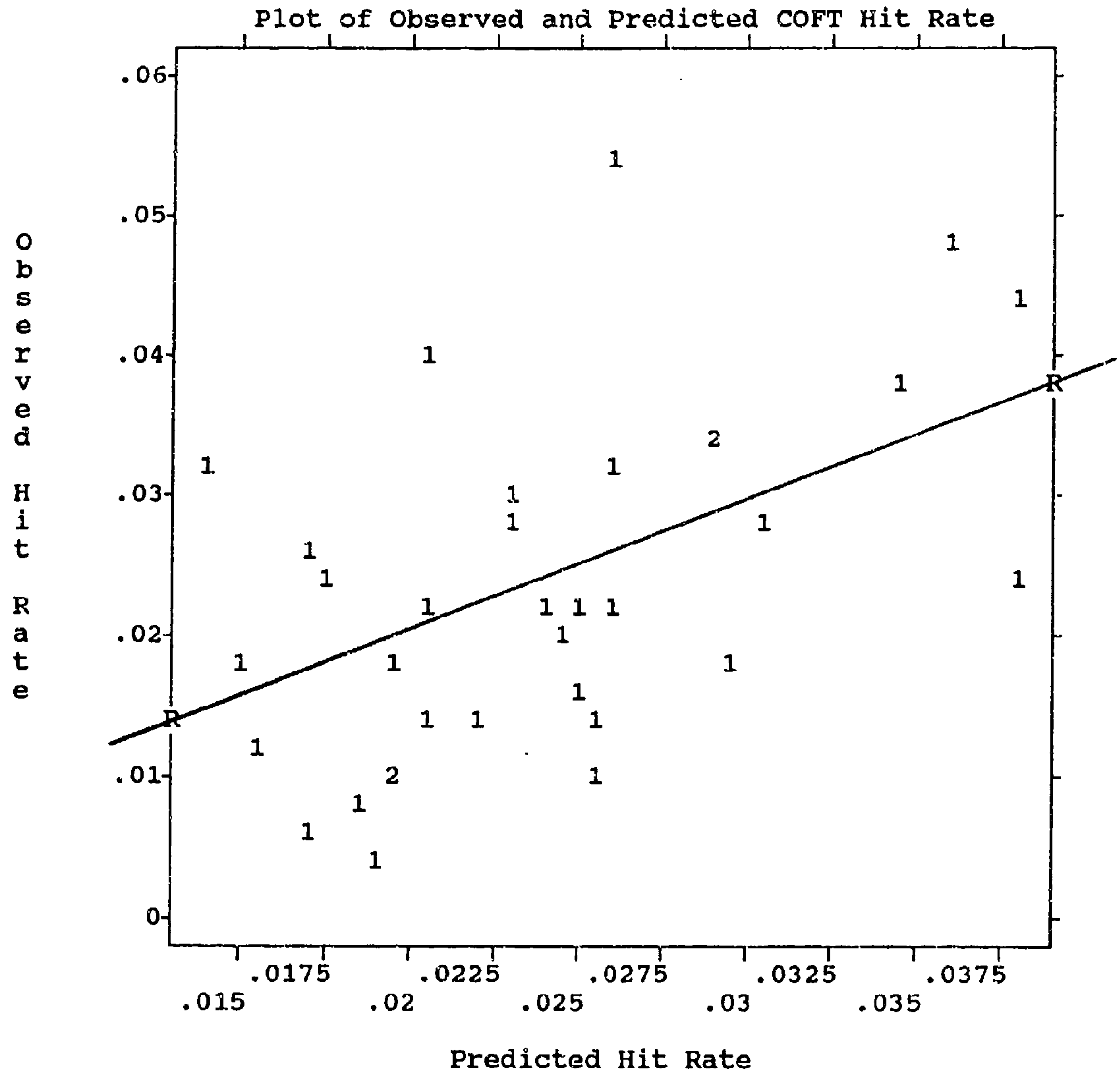

Figure 5. Plot of observed and predicted COFT hit rate for both groups combined (N = 34; r = .52; p = .002). Predicted hit rate = - .003850 + .00273 (gunner's rank) + .001114 (TC rank) + .140576 (GUARDFIST fire rate).

data on gunner and TC demographic variables were handled by the mean substitution technique.)

Predicting GUARDFIST Hit Rate From COFT Test Scores and Crew Demographics

Three predictor variables (amount of TC experience with closed hatch day searches, gunner's rank, and COFT Exercise 1 Hit Rate) also successfully modelled GUARDFIST Hit Rate, $R = .51$, $F(3, 30) = 3.44$, $p = .029$. Crews with higher ranking gunners, TCs with more experience conducting closed hatch day searches, and high COFT Hit Rate scores also obtained higher GUARDFIST Hit Rate scores. Figure 6 graphically depicts the relationship between the obtained and predicted GUARDFIST Hit Rate scores. (Missing data on gunner and TC demographic variables were handled by the mean substitution technique.)

Accuracy of Device-based Training Time Estimates

COFT training times ranged from 53 min to 183 min, with a mean of 113 min (SD = 44 min). GUARDFIST training times ranged from 85 min to 271 min, with a mean of 163 min (SD = 51 min). Greater GUARDFIST training times resulted from the availability of two GUARDFIST devices versus only one COFT device at each participating armory.

Crews receiving COFT training advanced through the matrix at the rate of one exercise every 29.08 min. The interim training strategy (Morrison, Campshure & Doyle, 1990, pp. 20-23) recommends 13 2-hr COFT training sessions, or a total of 26 training hr. If the training rate obtained by tank crews in this investigation is assumed to be constant throughout the training matrix, 26 hr would provide enough time to complete approximately 54 COFT training exercises.

The COFT TC/gunner training matrix contains 510 exercises (390 European Environment and 120 Desert Environment). Advancement through the matrix is governed by "matrix movement rules" which permit crews to skip many of the exercises (see General Electric, 1989). The exact number of exercises (and the combination of specific exercises) required for certification differs for every training crew, depending on their performance on the three evaluative dimensions of target acquisition, reticle aim, and systems management. Thus, no two crews require the same number of exercises in order to reach certification. On the basis of matrix advancement rates from the present investigation, it is not possible to evaluate if 26 hr, as provided in the interim strategy recommendations, is sufficient time to complete the recommended exercises and achieve COFT certification. Moreover, it is unknown if the training rate observed in this research could be sustained throughout the entire COFT training matrix. On the one hand, the rate might slow as crews advance

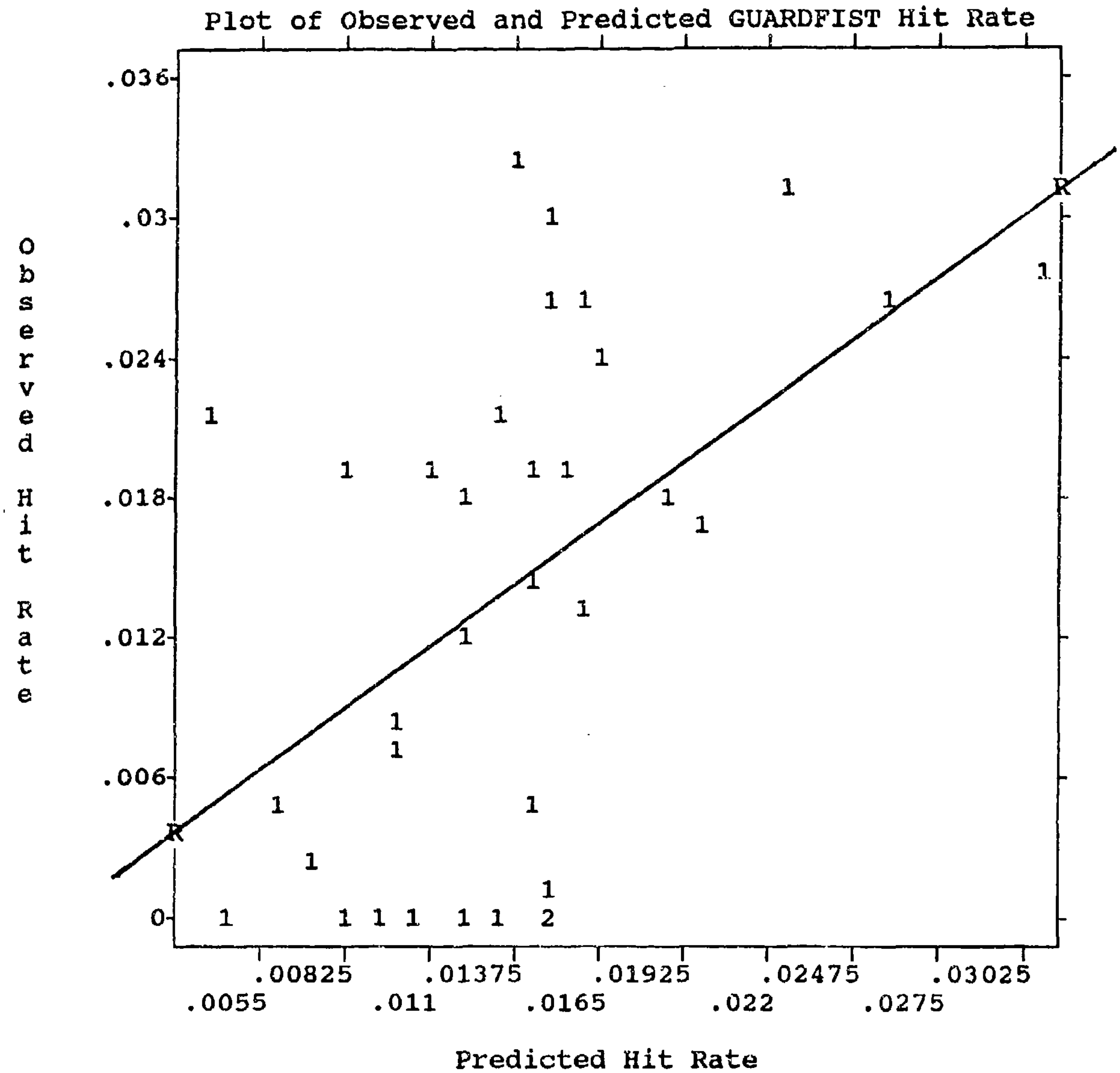

Figure 6. Plot of observed and predicted GUARDFIST hit rate for both groups combined (N = 34, r = .51, p = .002). Predicted hit rate = - .012469 + .003896 (TC experience with closed hatch day searches + .001767 (gunner's rank) + .090133 (Exercise 1 hit rate).

into more difficult levels of the matrix. On the other hand, a definite learning curve should occur as a result of repeated exposure to the training device and related engagement exercises.

Crews receiving GUARDFIST training advanced through the matrix at the rate of one exercise every 4.85 min. The interim training strategy (Morrison, et al., 1990, pp. 20-23) recommends 16 1-hr GUARDFIST training sessions, sufficient time to complete approximately 198 training/evaluation exercises, if the training rate obtained by tank crews in this investigation is constant throughout the GUARDFIST training matrix.

The interim training strategy recommends completion of all training exercises through Group 6 in the GUARDFIST training matrix plus completion of 9 additional diagnostic exercises, for a total of 145 exercises. Completion of the recommended exercises at the rate of advancement observed in the current investigation would require approximately 12 hr. Thus, the interim strategy allows ample time to complete the recommended number of exercises. In fact, the allocated 16 hr in the interim strategy is approximately 33% more time than needed, as indicated by advancement rates obtained in the current investigation. However, it is unknown if the training rate observed in the current research can be sustained throughout the entire GUARDFIST training matrix. Advancement rates were based predominantly on defensive engagements, and may differ for subsequent offensive engagements. According to Morrison, et al. (1990, pp. 26-27) total run time for recommended GUARDFIST basic training exercises is 40 min. Total run time for intermediate exercises (Groups 5 and 6) is 50 min. For this reason alone, advancement rates may slow somewhat as crews progress further into the matrix. Therefore, the current 16 hr recommendation seems prudent until additional normative data are collected.

Discussion

Prior COFT training produced significantly better GUARDFIST test performance in terms of both gunnery speed and accuracy. Prior GUARDFIST training produced significantly better COFT test performance in terms of speed if crews advanced far enough into the training matrix to complete multiple offensive engagements.

In Group 1, advancement into the COFT training matrix was the best predictor of subsequent GUARDFIST posttest scores. In turn, advancement into the COFT training matrix was predictable from COFT pretest scores. Greater advancement into the training matrix was obtained by crews that achieved high pretest Fire Rate scores.

In Group 2, Trial Efficiency, a measure of tank crews' speed of advancement through the GUARDFIST training matrix, was significantly related to a host of subsequent COFT test scores

(Exercise 1 Hit Proportion, overall Hit Proportion, Exercise 1 Hit Rate, and Proportion of Targets Fired On). The relationship between Trial Efficiency and other posttest scores approached statistical significance (overall Hit Rate, Exercise 1 Fire Rate, and Targeting Efficiency). Higher COFT posttest scores were not obtained by crews that trained longer, but by crews that trained more efficiently. Moreover, crews that trained more efficiently were those that achieved high pretest scores. Correlations between GUARDFIST pretest scores and subsequent GUARDFIST training efficiency were as high as r = .86, p = .001 (for Fire Rate). Completion of multiple offensive GUARDFIST training engagements was associated with significantly enhanced COFT posttest Fire Rate scores. Differences in COFT Hit Rate scores approached statistical significance.

Thus, the pattern that emerged for both training groups was that high pretest scores predicted training success on the same device. Training success, in turn, predicted subsequent posttest scores on the alternate device (the one on which they received no training). In the GUARDFIST training group the best training predictor of subsequent COFT posttest scores was efficiency of training (although maximum matrix advancement and completion of multiple offensive training engagements also were useful predictors). In the COFT training group the best training predictor of subsequent GUARDFIST posttest scores was maximum matrix advancement. In the GUARDFIST training group amount of training time was actually negatively correlated with subsequent posttest scores. This result did not occur in the COFT training group and was probably due to the fact that two GUARDFIST devices were available for training in each armory where GUARDFIST training was conducted, whereas only one COFT device was available in COFT-training armories. GUARDFIST crews trained longer than COFT crews, and it was possible for less proficient crews to receive longer training sessions. This luxury was not available in COFT training armories.

Device scores were significantly, but moderately, intercorrelated. Hit Rate from the two devices correlated significantly. Moreover, GUARDFIST Fire Rate was significantly related to both COFT Hit Rate and Hit Proportion, and the relationship between COFT Fire Rate and GUARDFIST Fire Rate approached statistical significance. In view of the duration of training (producing a lengthy test-retest time interval), the modest interdevice relationships are not surprising. Stronger linkages occurred between more temporally contiguous measures: pretest scores with training measures, and training measures with posttest scores. Table 10 demonstrates that most of the relationship between overall COFT and GUARDFIST scores was traceable to only one of the two COFT exercises, and points up both the critical importance of exercise selection and, consistent with the recommendations of Smith and Hagman (199?), the need to incorporate at least four exercises into a COFT or

GUARDFIST test. Smith and Hagman found that Hit Rate based on individual COFT exercises did not reliably predict Table VIII scores, but that Hit Rate based on the combination of four exercises produced a robust correlation. This suggests that the observed interdevice correlations are probably conservative, and probably would be more robust if it had been possible to use longer COFT and GUARDFIST tests.

The addition of demographic measures boosted the modest interdevice correlations. With COFT test scores as the criterion, the addition of gunner's rank and TC rank to the prediction equation raised a bivariate r = .29 to a multivariate R = .52. For GUARDFIST scores the addition of gunner's rank and TC's experience with closed hatch day searches produced a similar increment. As was the case in predicting Table VIII scores (Smith & Hagman, 1992), demographic variables played a significant role in predicting both COFT and GUARDFIST scores. Gunner's rank and TC rank are especially interesting as predictor variables because neither was consistently related to the 13 measures of tank gunnery experience. Only 1 of 26 correlations was significant, and it was negative -- between gunner's rank and amount of experience with performing prepare-to-fire checks. Rank may serve as a marker variable for underlying motivational influences, and it may be these motivational influences that impact test and training performance.

Are device-based training time estimates accurate? The present research supports the interim strategy recommendation of 16 GUARDFIST training hrs. Although recommended hrs may be slightly liberal, based on the observed rate of advancement, it will be recalled that the rate was based on predominantly defensive engagements. Rate of advancement through offensive engagements may be slower. It should also be noted that in situations where GUARDFIST training time is limited, a preferred strategy might be to skip some of the defensive training engagements that appear early in the matrix, in order to present a more balanced combination of defensive and offensive engagements within the allotted training schedule.

The interim strategy's recommended 26 COFT training hrs is more difficult to evaluate. The results obtained in the present investigation suggest that approximately 54 exercises can be completed in 26 training hrs. It is unknown, however, how many COFT exercises must be passed in order to achieve certification. Thus, evaluation of the interim strategy recommendation of 26 training hrs awaits collection of normative data concerning how many completed exercises are typically required to reach various points in the matrix.

One piece of information is missing for both devices. Is it necessary to complete the entire training matrix in order to insure subsequent Table VIII qualification? If not, then how far into each training matrix must a crew advance? Smith and Hagman (1992) demonstrated that a combination of COFT test scores and demographic variables can successfully predict Table VIII scores. That research, however, was based on test scores and not matrix advancement. Thus, it is currently unknown what level of matrix advancement is necessary to insure Table VIII qualification. This would indeed be a useful piece of information, and it is recommended that future research address this need.

Conclusions and Recommendations

The positive transfer and correlational findings of the present research suggest that COFT and GUARDFIST can be used interchangeably to improve the speed of device-based tank gunnery engagements, whereas COFT should be used for improving their accuracy. If both devices are to be used for training, then the most effective/efficient device usage sequence would be COFT first, then GUARDFIST, at least for Table VIII-related engagement conditions found in common in the training matrices of the two devices. Thus, the order of device usage during training will make a difference when improved accuracy is the objective.

Given that GUARDFIST training did result in COFT accuracy improvements that approached statistical significance, it is premature to rule out the possibility of GUARDFIST-to-COFT transfer in regard to accuracy without doing additional research with larger sample sizes and longer training intervals than those reported here. In addition, research is needed to identify the amount of transfer to live-fire performance that can be expected from training on each device both individually or in combination. Research to determine this device to live-fire transfer is currently underway.

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Appendix A

Descriptions of Physical and Instructional Features of COFT and GUARDFIST

M1 M-COFT

The Mobile Conduct-of-Fire Trainer (M-COFT) is composed of four components: (a) the general purpose computer (GPC), which receives, transmits, and calculates data during training and maintenance on the device; (b) the special purpose computer (SPC), which produces the visual images viewed by the TC and gunner; (c) the Instructor/ Operator (I/O) station, which the I/O operates to initiate the exercise, interact with the crew during the exercise, and monitor the crew's performance; and (d) the crew station, which simulates the TC and gunner stations of an M1 tank. Figure A-1 presents a cut-away view of an M-COFT. M-COFT is actually a transportable U-COFT. The description of the device that follows is based on documentation for the U-COFT, namely the Instructor's Utilization Handbook for the M1 Unit-Conduct of Fire Trainer (U-COFT) (General Electric, 1985) and the M1 Unit Conduct-of-Fire Trainer (U-COFT) Training Device Support Package, FC 17-12-7-1 (U.S. Army Armor Center, 1985). Both of these publications contain extensive descriptions of U-COFT's components, characteristics, and capabilities.

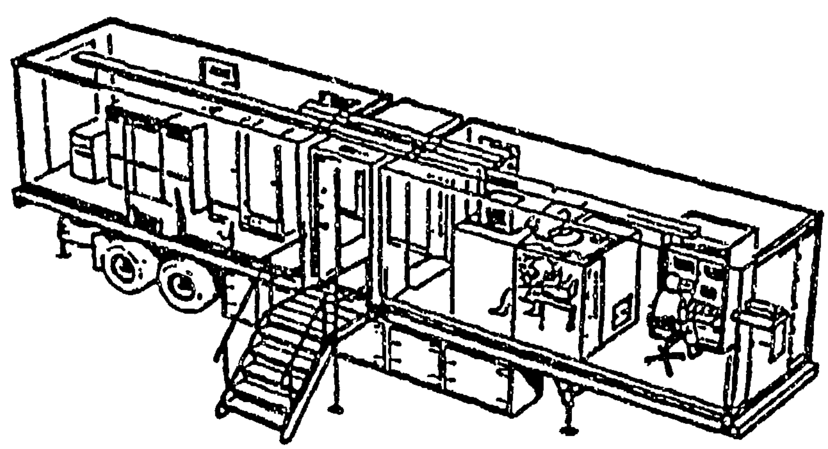

Figure A-1. The Mobile Unit Conduct-of-Fire Trainer (M-COFT).

Fidelity Features

Full-color, computer-generated visual scenes on M-COFT are created by the SPC and are viewed in the simulated TC and gunner crew stations through the (a) gunner's primary sight (GPS), (b) gunner's auxiliary sight (GAS), (c) gunner's primary sight extension (GPSE), (d) commander's weapon sight, and (e) commander's forward unity periscope (FUP). The visual scenes simulate a[n] area three kilometers in depth and six kilometers in width. M-COFT provides two data bases, one representing European terrain and the other depicting desert terrain. Each data base contains an assortment of features that define its specific environment, such as trees, rocks, hedges, and various buildings. These features serve to enhance the realism of the terrain and to provide objects for masking targets. Targets in the visual scenes are presented as either single or multiple (two or three) and as either moving or stationary. Targets are programmed to appear at different points on the data base and appear at a variety of different angles and positions. Both threat targets (T72, BMP, HIND-D, trucks, and troops) and friendly targets (M60A3, M1, and M2/M3) are presented on the simulated terrain. M-COFT also simulates the ability to "maneuver" through the data base, allowing crews to simulate engaging targets from a moving vehicle.

M-COFT simulates six different visibility conditions including (a) day unlimited (b) day with haze (c) day with fog, (d) dawn/dusk, (e) night unlimited (thermal mode), and (f) night with thermal clutter. In addition, a number of visual special effects are produced including initial firing, scene obscuration, round tracer and tracer paths, round impact and effect on target, round impact on terrain, friendly fire from flanks, enemy direct/indirect fire, and hit on owntank.

A number of sounds associated with tank gunnery in a combat environment are produced by the M-COFT sound system. These sounds include owntank weapon fire (main gun, coax, caliber .50, and smoke grenade), friendly fire, enemy fire, tank track clatter, engine and transmission sounds (idle, turning, varying speeds), the TIS cooling fan, the turret blower fan, gun jump sounds (associated with activating the palm switches while stabilization is in effect), loading of the main gun (loader's announcement of "up", breech opening/closing, round removal, expended casings falling, ammo doors opening), and hits on owntank. Sounds are presented to the TC and gunner through CVC helmets which are connected into M-COFT's radio/intercom system. This system also allows the I/O to communicate with the TC and gunner.

The TC and gunner stations in M-COFT simulate the actual M1 vehicle controls, sights, and indicators that are required for gunnery training. In the gunner's station, all of the sights and control panels present in the M1 are represented and functional with the exception of the hydraulic pressure gage, the gunner's unity periscope, the ammunition temperature gage, and the gunner's TIS focus knob which are represented but not functional. The gunner's seat, chestrest, domelight, and ballistic doors handles are replicated. Automatic firing of the coax machine gun and operation of the charging handle used to apply immediate action for stoppages are simulated; however, manual firing of the coax is not simulated. In the TC's station, the commander's control panel is replicated and functional with the exception of the LOW BAT CHG, CKT BKR OPEN, and ENGINE FIRE lights which are represented but not functional. The TC's seat, domelight, and kneeguards are simulated, but the hatch is not. Partially simulated are the TC's periscopes (only the FUP is represented) and the caliber .50 machine gun. Closed-hatch firing of the caliber .50 is possible, but open-hatch manual firing is not. In addition, the radio/ intercom and the gas particulate filter system are simulated in both crew stations.

The degraded modes simulated by M-COFT are (a) LRF failure, (b) stabilization failure, (c) GPS/TIS failure, (d) gunner's power control handle failure, (e) electrical triggers failure, (e) ballistic computer failure, (f) commander's weapon station (CWS) power failure, (g) commander's power control handle failure, and (h) coax stoppage. Not simulated are failures associated with the crosswind, cant, and lead angle sensors.

Instructional Features

The instructional subsystem of M-COFT is quite complex and, to a certain extent, dictates how M-COFT is used. Thus, it deserves special attention. This instructional system provides for 685 exercises divided into three major categories: (a) special purpose, (b) commander, and (c) commander/gunner exercises. The 19 special purpose exercises are manually selected by the I/O and are used to orient crews to the device; to train crews to place the crew stations into operation, boresight and calibrate/zero weapons, detect targets and manipulate controls on M-COFT; and to evaluate the crew's proficiency on the device. There are 156 commander exercises (126 European and 30 desert exercises) designed to develop or sustain the gunnery skills of TCs. Each commander exercise contains from five to ten targets grouped into single target situations and is fired by the TC alone. There are also 510 commander/gunner exercises (390 European and 120 desert exercises) designed to train crew gunnery skills. The commander/gunner exercises contain up to ten targets grouped into either single or multiple target situations.

The commander and commander/gunner exercises are organized into two separate training matrices. Each matrix is made up of three dimensions which represent critical skill areas associated with tank gunnery training. Those dimensions are: (a) target acquisition (TA), which includes target identification and acquisition skills; (b) reticle aim (RA), which includes aiming and firing skills; and (c) system management (SM), which includes skills necessary to operate the fire control system. As a TC progresses along a particular dimension of the commander matrix, or a TC/gunner pair advances along a particular dimension of the TC/gunner matrix, the difficulty of the corresponding skill area increases. The commander and commander/gunner matrices are shown in Figures A-2 and A-3, respectively.

The commander matrix comprises three levels of target acquisition. Increases in TA difficulty are attained by reducing visibility and adding distractions for the crew. TA Level One contains exercises fired under unlimited day visibility conditions. The exercises in TA Level Two are conducted under dawn/dusk visibility conditions. TA Level Three is made up of exercises conducted under day visibility conditions with haze and with friendly and enemy fire, to simulate the distraction of an actual day combat environment. The level of difficulty in the SM skill area is increased by increasing the range to the targets presented within an engagement. Overall progress in the matrix proceeds along the RA dimension. Increases in RA difficulty are attained by introducing system malfunctions into the simulation and by changing the movement of owntank and targets. The RA dimension is divided into 21 levels which are organized into five groups according to owntank and target movement situations. As shown in Figure A-2, the 21 RA levels are combined into five RA groups defined by movement of the owntank and movement of the targets.

As shown in Figure A-3, the commander/gunner matrix is similar in organization to the commander's matrix. The commander/gunner contains three levels of TA which increase in difficulty as visibility diminishes and distractions are added. TA Level One includes exercises fired under either unlimited day or unlimited night visibility conditions. The exercises in TA Level Two are conducted under the reduced visibility conditions of dawn/dusk, night with thermal clutter, or day with fog and thermal clutter. The exercises in TA Level Three are conducted under hazy day conditions with friendly and enemy fire or under night conditions with thermal clutter, and friendly and enemy fire. As in the commander matrix, RA increases in difficulty as malfunctions are introduced into the system and the movement of owntank and target changes. There are 39 levels of RA difficulty in the commander/gunner matrix, which are arranged into six RA groups. The exercises are similarly grouped according to combinations of owntank and target movement; as shown in Figure A-3, however, there are six rather than five RA groups. The certification exercises used to qualify crews on M-COFT comprise RA Group Six. Finally, there are four SM levels in the commander/gunner matrix, which increase in difficulty as the range and number of targets presented increase.

A crew's specific entry point into each matrix and the point at which it reaches certification are dependent on the amount of prior training it has received and their proficiency level on the device. That is, crews with little or no prior gunnery experience begin at, progress through, and are certified on the easier TA and SM levels. Upon achieving certification they then reenter the matrix at the sustainment level. Experienced gunnery crews enter the matrix at the sustainment level and progress through and are certified on the more difficult TA and SM levels. Crews are allowed to advance through the matrices at their own pace. Progression through the matrices is controlled by matrix movement rules, which are different for each of the four levels of training on M-COFT (sustainment, transition, cross, and basic). The movement rules are designed to prohibit crews from advancing to the next higher level of difficulty until they have demonstrated an acceptable level of mastery within a dimension

After each exercise is completed, the GPC calculates a score for the crew on each of the three skill areas and develops a recommendation pertaining to the crew's movement within the matrix. The four recommendations the computer can make are: (a) reduction in level, (b) no advancement, (c) normal advancement, and (d) rapid advancement. The computer then checks this recommendation against the matrix movement rules to determine the next exercise to be fired. Briefly stated, in order to advance to the next higher difficulty level within a skill area, a crew must perform at or above a minimum acceptable proficiency level, and they must attain a normal advance computer recommendation on all three dimensions on the "gate" exercise within each RA group in the matrix. These exercises are gates in the sense that they must be successfully passed before proceeding to the next RA group. In the commander matrix, the gate exercise in each RA group is the most difficult exercise that contains no system malfunctions. In the commander/gunner matrix, the gate exercise in each RA group is the most difficult NBC exercise.

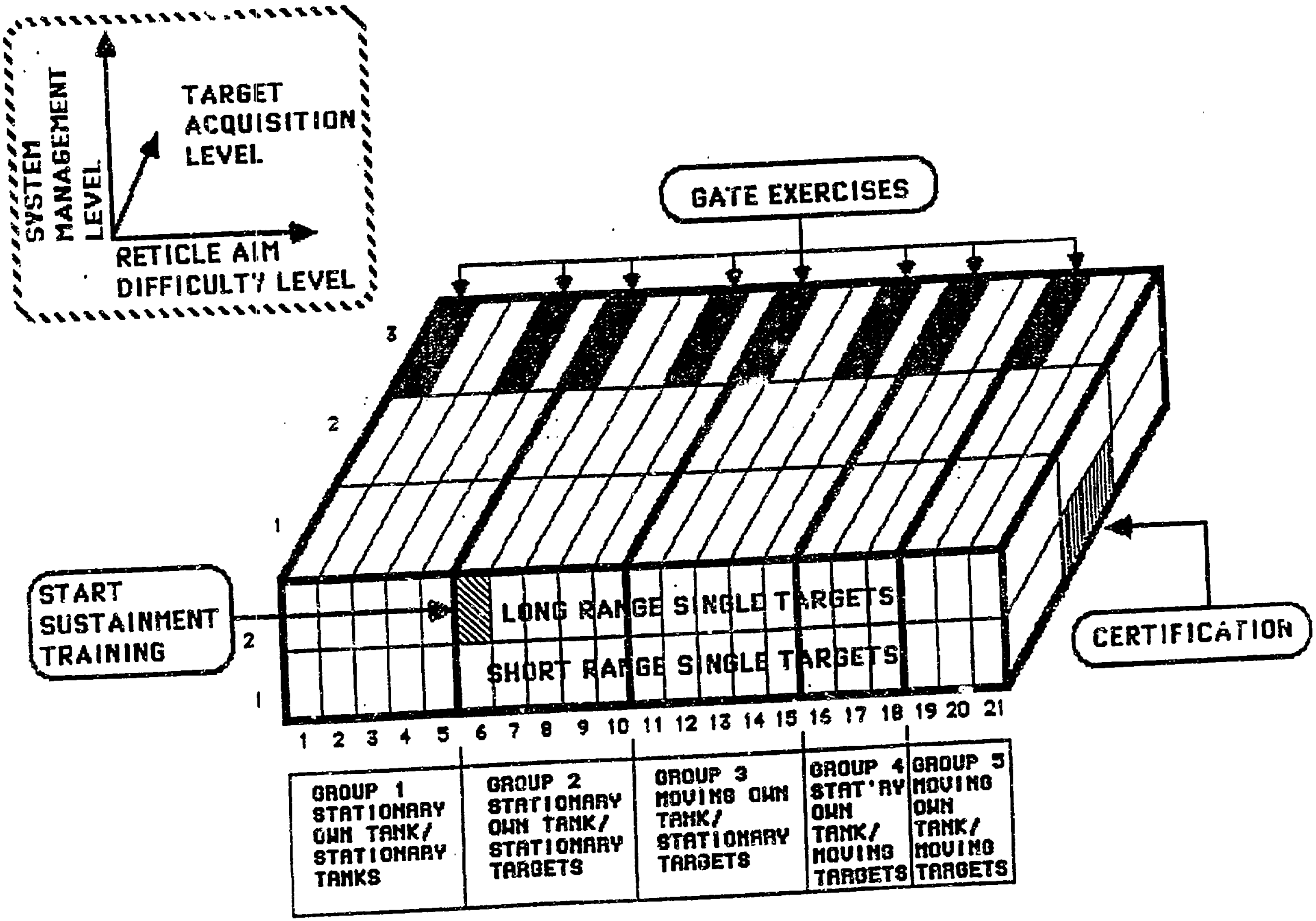

Figure A-2. M-COFT commander training matrix.

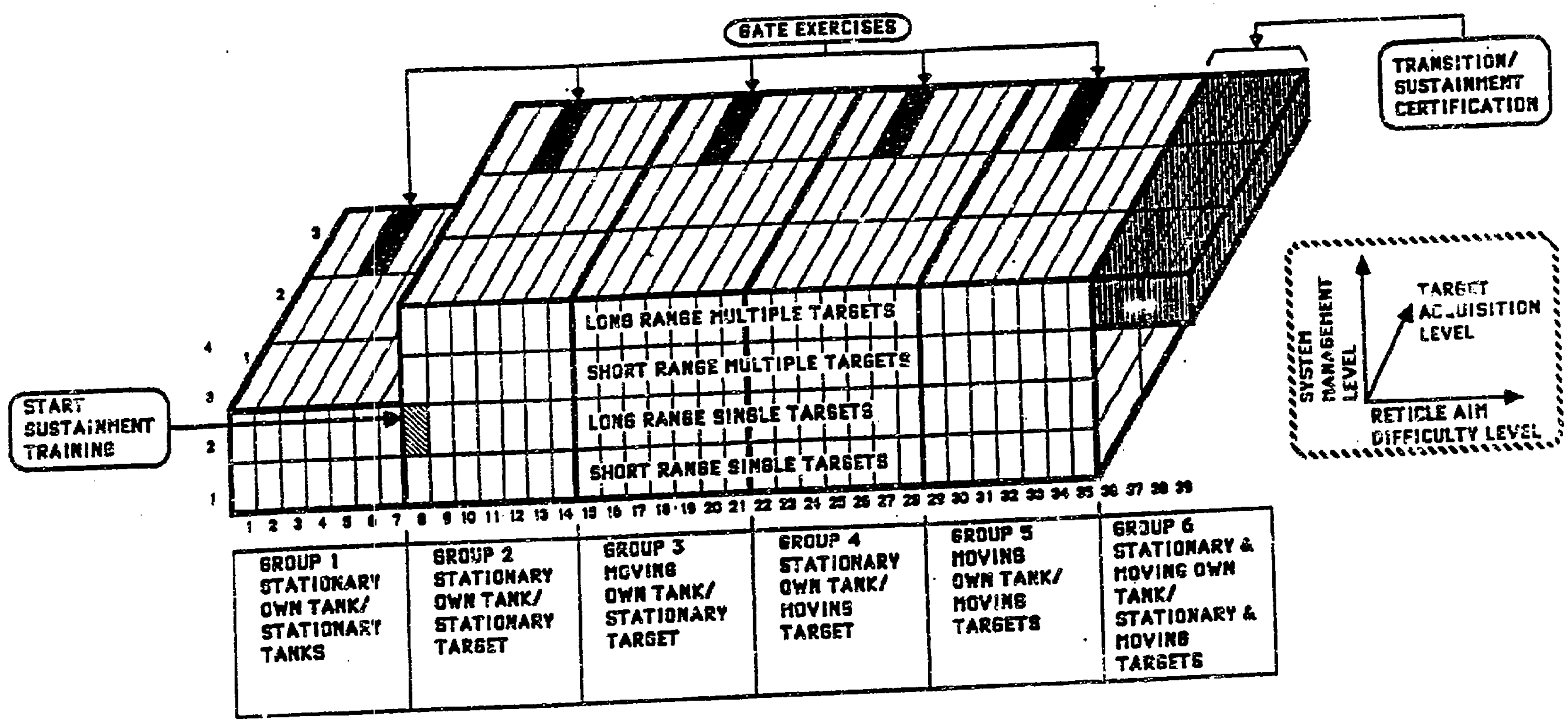

Figure A-3. M-COFT commander/gunner training matrix.

In addition to the automatic sequencing recommended by the M-COFT training program, the I/O has the option of manually selecting exercises to emphasize certain skill areas. In scoring these optional exercises, the GPC calculates a letter "grade" (A, B, C, or F) rather than recommending a level of advancement. Performance on I/O selected exercises is not taken into account by the GPC when regulating advancement through the matrices.

Currently under development is an advanced matrix for the U/M-COFT which will replace the present commander and commander/gunner matrices as the primary training software. Tentatively scheduled for release in May 1991, the advanced matrix is being designed because many crews have difficulty advancing beyond RA Group Two in the commander/gunner matrix. This situation poses a problem in that most Major Commands require crews to pass "gate" COFT exercises as a prerequisite to live-fire training; many of the exercises selected as these gates are beyond RA Group Two. Thus, at present, many crews that have not passed RA Group Two are temporarily withdrawn from the matrix to fire the gate exercises and then placed back into the matrix at their previous level. The new matrix avoids this predicament by positioning exercises commonly used as gate exercises at the end of RA Group One. In addition, the advanced matrix will allow the TC the option of deciding how to fight the tank. That is, as long as the crew's actions result in hits or kills, the TC can choose battlesight over precision, or use the GAS instead of the GPS and not be penalized. Also, unannounced malfunctions will be randomly induced into exercises, requiring the crew to make the appropriate adjustments. Finally, the hit plate on targets will be reduced, so that some targets may require two or more rounds before a kill is registered.

With regard to performance measurement capabilities, the GPC automatically keeps track of individual, crew, and unit progress through the M-COFT training matrices. This information can be accessed by the I/O in the form of printouts that can be used to provide the crews with feedback on their performance. With regard to individual crew performance, six printouts are available:

- Situation Monitor - provides information on ammunition selected, target type, reticle lay, number of rounds fired, engagement result, and letter grades for each of the three skill areas.

- Performance Analysis - provides information on target type, number of rounds fired at each target, number of main gun hits and percent of machine gun coverage, TA and SM errors, individual engagement scores, the GPC recommendation for each of the three skill areas, and individual and average times to identify, fire, hit, and kill targets.

- Shot Pattern - depicts reticle lay error in both graphic and tabular formats.

- Session Summary - provides a summary of the crew's last training session. The printout contains, by exercise, the total number of rounds fired, total number of hits, number of targets engaged, total number of TA and SM errors, the GPC recommendation or letter grade for each skill area, and the average times to identify, fire at, hit, and kill targets.

- Crew record - provides a record of the last 100 exercises fired by the crew and the GPC recommendation or letter grade for each skill area for each exercise. It also includes coordinates that indicate the crew's present and expected positions in the matrix, the number of GPC recommended exercises fired, whether the TC and/or gunner are certified, and a summary of the crew's progress in the commander/gunner training matrix.

In addition to the matrix and performance measurement features, Hoffman and Morrison (1988) identified a number of additional instructional features that are incorporated on the U-COFT. These features include the ability to (a) select exercises according to a set of parameters, (b) record and replay the visual and aural cues from an exercise, (c) freeze and unfreeze action during an exercise, (d) repeat any portion of an exercise, (e) continuously monitor the sight pictures presented to the TC and gunner from the I/O station, (f) automatically record errors relating to improper positioning of switches, and (g) provide a written briefing on upcoming exercises that the I/O can deliver to the TC and gunner.

GUARD FIST I

The Guard Unit Armor Device Full-Crew Interactive Simulation Trainer, Armor (GUARD FIST I), consists of three sets of components. According to the Operator's Manual for GUARD FIST I (Daedalean, Inc., 1990) those three sets of components are (a) the components that are appended to an actual M1 tank, (b) the instructor/operator (I/O) station, and (c) the cable harness that connects the tank-appended components to the instructor/operator station. The harness transmits information from crewmember's controls to the computer, and transmits information from the computer to the tank controls. The components of the device are pictured in Figure A-4. A complete description of GUARD FIST I components and functions can be obtained in the Operator's Manual.

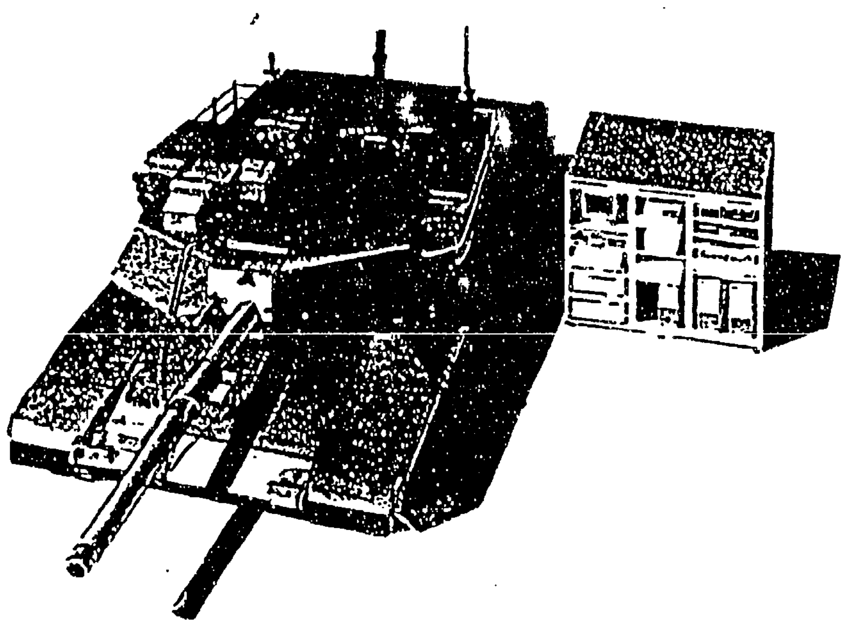

Figure A-4. The Guard Unit Armor Device Full-Crew Interactive Simulation Trainer, Armor (GUARD FIST I).

Fidelity Features

The device's visual images are provided to the crewmembers via four 16-inch, high resolution, color monitors. The four monitors are placed outside of the tank in front of (a) the gunner's primary sight (GPS), (b) the gunner's auxiliary sight (GAS), (c) the tank commander's weapon station (CWS) vision block, and (d) the driver's center vision block. These pictures on the monitors simulate the scenes that would be viewed from these four sights. Three types of stationary or moving threat targets are presented in the visual scenes, each requiring different weapon/ammunition combinations: (a) heavily armored vehicles (T72), which should be engaged with the main gun using APDS rounds; (b) lightly armored vehicles (BMP, ZSU 23-4, and BRDM), which should be engaged with the main gun using High Energy Anti-Tank (HEAT) rounds; and (c) "soft" targets (infantry personnel), which should be engaged with the coaxial machine gun. Also projected is background scenery appropriate to either a European or a desert scenario.

During GUARD FIST I exercises, a sound generating system synthesizes the sounds corresponding to various actual sources associated with tank gunnery including the main gun and coax machine gun, the ready ammo door, the engine, the turret blower, and the compressor on the thermal imaging system. These sounds are transmitted through the intercom system and through a pair of bass and treble speakers mounted under the breechblock. GUARD FIST I supplies power to the intercom boxes so that these tank components can be used with actual CVC helmets for intratank communications. The intercom system also allows the instructor/operator (I/O) to communicate with the crew. GUARD FIST I also supplies power to the individual domelights at all stations; these tank components function as they would if the tank were powered up. The following paragraphs describe the controls and displays that function at each crewmember's station.

At the commander's control panel, two controls related to battlesight engagements function normally: the MANUAL RANGE BATTLE SGT pushbutton and the MANUAL RANGE ADD-DROP switch. Also on the commander's control panel, the FIRE CONTROL MALF comes on at appropriate times during the training and evaluation exercises. The control handles at the CWS simulate the traversal of the CWS by changing the CWS display; that is, the cupola does not move, but the simulated scene does. The CWS does not allow the tank commander to fire his caliber .50 machine gun as that weapon system is not simulated in GUARD FIST I. The commander's power control handle functions as it normally would to override/operate the gunner's power control handles. That is, this handle allows the tank commander to elevate/traverse the turret, activate the LRF, and fire the main gun or coaxial machine gun.

At the gunner's station, a faceplate mounts directly in front of the gunner's control panel providing a simulation of some of the controls on that panel including the RANGE switch, the FIRE CONTROL MODE switch (the MANUAL setting is not functional), the GUN SELECT switch, and the AMMUNITION SELECT switch. TIS controls that are functional include the FLTR/CLEAR/SHTR switch, the THERMAL MAGNIFICATION switch, and the POLARITY switch. The remaining controls on the gunner's control panel overlay are nonfunctional two-dimensional representations of the actual equipment. The RETICLE switch on the GAS control panel enables the gunner to change between the SABOT/HEAT combination reticle and the HEAT reticle as he would in the actual tank. Finally, the gunner's control handles function as they do in the tank to elevate/traverse the turret, activate the LRF, and fire the main gun or coaxial machine gun.

At the loader's station, the loader's control panel simulates two functions of the panel controls and displays: (a) the GUN/TURRET DRIVE switch can be placed in EL UNCPL or POWERED positions as appropriate (the MANUAL position does not work), and (b) the MAIN GUN STATUS lights (ARMED and SAFE) illuminate to indicate the position of main gun spent case ejection guard. The loader's knee switch functions normally to allow the loader to choose ammunition in the ready rack. However, the ready rack door does not open as it does in the tank; rather, the loader chooses ammunition by depressing either the HEAT or SABOT button on the ammunition select panel. This latter panel is not in the operational tank. Another component not on the actual tank is the breech load select switch. After an appropriate interval, the READY light on top of the breech load select switch illuminates to indicate that the loader can simulate loading the round into the breech. This action is simulated by pushing a spring-loaded button in the center of the breech load select switch. At that point the READY light goes out and the LOADED light comes on. The loader completes the loading procedure by moving the ejection guard to the FIRE position as he would in the actual tank.

At the driver's station, sensors are attached to detect (a) changes in the steering column to determine the direction the tank is steered, (b) the position of the throttle, and (c) position of the service brake, and (d) the transmission gear selected. These sensors feed information into the computer which makes appropriate changes to the computer-generated images in each of the monitors. Except for these four controls, none of the other components at the driver's station operate.

GUARD FIST I simulates a number of degraded modes including LRF failure, GPS/TIS failure, loss of symbology in the GPS, and loss of stabilization. However, it does not simulate turret power failure and thus does not support training for operating the tank in manual mode.

Instructional Features

The trainer has access to a total of 36 training exercises arranged in six groups of six exercises. In addition to the six training exercises, each group has three evaluation exercises. Each training or evaluation exercise consists of two or more tasks (single- or multiple-target gunnery engagements). The six groups are ordered in difficulty from easiest to most difficult. The groups are distinguished on multiple dimensions of engagement conditions. For instance, in the first group, crews engage fully exposed, single stationary targets presented at moderate ranges from a stationary owntank experiencing no malfunctions. In contrast, the sixth group requires crews to engage fully and partially exposed, multiple, stationary and moving targets at short to long ranges from a moving tank experiencing a variety of unannounced malfunctions. The overall training strategy calls for crews to practice on training exercises within one group. When the I/O deems that the crews are prepared, they take one or more of the evaluation exercises. They must pass the evaluation exercise for that group in order to go to the next group in the series.

GUARD FIST I can be run in one of two modes. In the primary mode, the I/O selects and runs training and evaluation, and can perform all crew record and management functions. The crew records maintained by GUARD FIST I include such information as the crew identification number, the current exercise group, whether or not crew has qualified in the group and the date of qualification, and the number of times specific exercises were run, failed, and/or passed. In the secondary mode, the tank commander car select and run training exercises through the use of a keypad that is appended to the left of the GPSE. However, the tank commander cannot run evaluation exercises, nor does he have access to crew records.

The I/O station provides two monitors (gunner/driver and tank commander), which operate in two modes. In "realtime" mode, the gunner/driver monitor can be switched back and forth between the views from either the gunner or driver's monitors. For the view from the gunner's monitor, the default condition is to show the GPS. However, if the gunner places his head in the GAS and trips an appended infrared sensor, the gunner display at the I/O station automatically switches to the GAS. At the same time, the tank commander monitor shows the view from the CWS vision block. In "non-realtime" mode, the system displays menus through the gunner/driver monitor, and a test pattern is displayed at the tank commander monitor. In addition to the monitors, the I/O has a standard QWERTY keyboard for interacting with GUARD FIST I software. One function of this keyboard allows the I/O to freeze an engagement within an exercise by depressing a function key (F12). When an exercise is frozen, a menu is presented in the gunner/driver monitor offering the I/O the option to unfreeze the engagement, to restart the exercise, or to terminate the exercise.

GUARD FIST I has the capability to monitor errors that the crew commits during an exercise. Some errors are monitored automatically by the system itself. These errors are grouped into four levels of increasing seriousness: minor, important, major, and critical. A critical error (e.g., collision with an obstacle) results in automatic termination of exercise and a "fail" rating. Verbal responses cannot be monitored by the system, and are therefore keyed in by the I/O using the function keys on the QWERTY keyboard. For instance, the function keys F1-F9 are used to log in the elements of the fire command and other verbal announcements prescribed by gunnery doctrine.

At the end of either a training or evaluation exercise, a menu appears to allow the I/O to access and/or to print the Trigger Pull Error Report. This performance assessment provides basic hit/miss information as well as the owntank movement, target movement, target range, and type of round fired for each individual round fired. This report also provides a count of the number of errors committed for each pull of the trigger. From this screen, the I/O can access a page that identifies each error. If the exercise is for training, this screen allows the I/O to use the performance information and his own judgment to pass or fail the crew. If the exercise is for evaluation, the system automatically assigns the crew a pass/fail grade.

Appendix B

Modified Coft Training Matrix

Exercise	Sight	Tank	Target	TC-only	NBC
33211	GPS	S	S	NO	NO
33221	TIS	S	S	NO	NO
33311	GPS	M	S	NO	NO
33411	GPS	S	M	NO	NO
33421	TIS	S	M	YES	NO
33511	GPS	M	M	NO	NO
34531	GPS	M	M	NO	YES
34521	TIS	M	M	NO	NO
34461	GAS	S	M	NO	NO
34431	GPS	S	M	NO	YES
34331	GPS	M	S	NO	YES
34321	TIS	M	S	NO	NO
34261	GAS	S	S	NO	NO
34231	GPS	S	S	YES	YES

Appendix C

Modified GUARDFIST Training Matrix (E = Evaluation Exercise)

Grp/Ex	Task	Sight	Tank	Target	3-man	NBC
1/1	1-2	GPS	S	S	NO	NO
1/2	1-2	GPS	S	S	NO	NO
1/3	1-2	GPS	S	S	NO	NO
1/4	1-2	TIS	S	S	NO	NO
1/5	1-2	TIS	S	S	YES	NO
1/6	1-2	GPS	S	S	YES	NO
1/1	1-2E	GPS	S	S	NO	NO
1/2	1-2E	GPS	S	S	NO	NO
1/3	1-2E	GPS	S	S	YES	NO
2/1	1-2	GPS	S	S	NO	NO
2/2	1-2	GPS	S	S	NO	NO
2/3	1-3	GPS	S	S	NO	NO
2/4	1-3	GPS	S	S	NO	NO
2/5	1-3	TIS	S	S	NO	YES
2/6	1-3	TIS	S	S	NO	YES
2/1	1-2E	GPS	S	S	NO	NO
2/2	1-2E	GPS	S	S	NO	NO
2/3	1-2E	GPS	S	S	NO	YES
3/1	1-3	GPS	S	S/M	YES	NO
3/2	1-3	GAS	S	S/M	NO	NO
3/3	1-4	GAS	S	S/M	NO	NO
3/4	1-4	GPS	M	S/M	NO	NO
3/6	1-4	TIS	M	S/M	NO	NO
3/1	1-3E	GPS	S	S/M	YES	NO
3/2	1-3E	GPS	S	S/M	NO	NO
3/3	1-3E	GPS	S	S/M	NO	NO
4/1	1-2	GPS	M	M	NO	NO
4/3	1-4	GAS	S	S/M	NO	YES
4/4	1-5	TIS	S	S/M	NO	NO
4/6	1-4	TIS	M	S/M	NO	YES
5/1	1-3	GAS	S	S/M	YES	NO
5/2	1-5	GAS	S	S/M	NO	NO
5/3	1-4	GPS	M	S/M	YES	NO
5/4	1-6	GPS	M	S/M	NO	NO
5/5	1-3	TIS	M	S/M	NO	NO
5/6	1-3	TIS	M	S/M	NO	NO
5/1	1-5E	GAS	S	S/M	NO	NO
5/2	1-5E	GAS	S	S/M	NO	NO
5/3	1-5E	GAS	S	S/M	NO	NO
6/1	1-2	GPS	M	S/M	NO	YES
6/2	1-2	GPS	M	M	NO	YES
6/3	1	GPS	M	S	NO	NO
6/4	1	TIS	M	S/M	NO	NO
6/6	1-2	TIS	M	S/M	NO	NO
6/1	1-3E	GPS	M	S/M	NO	YES
6/2	1-3E	GPS	M	S/M	NO	NO
6/3	1-3E	GPS	M	S/M	NO	NO

Appendix D

Background Survey

1. Name ______________________________

2. Rank ______________________________ 3. Age ____

4. Do you have 20/20 vision without glasses or contact lenses?
   ___ Yes
   ___ No

   If no, do you wear glasses or contact lenses?
   ___ Yes
   ___ No

Throughout your military career, how much experience have you had with each of the following Armor crew-level activities? Rate your amount of experience on the tasks listed at the bottom of the page by circling a number from 1 to 5 that best tells how many times you have performed each task. Use the following scale:

1	2	3	4	5
Never	During 1 to 3 training events	During 4 to 6 training events	During 7 to 9 training events	During 10 or more training events

NOTE: A "training event" may be a Tank Gunnery Table, a Tactical Table, a GUARDFIST TRAINING session, an M-COFT training session, or some other gunnery exercise in which you practiced the task.

5. Perform prepare-to-fire checks	1	2	3	4	5
6. Acquire targets:					
Search during day with closed hatch	1	2	3	4	5
Search at night	1	2	3	4	5
Detect/locate/identify/targets	1	2	3	4	5
Evaluate situation	1	2	3	4	5
7. Engage single target with main gun					
Offensive precision gunnery	1	2	3	4	5
Defensive precision gunnery	1	2	3	4	5
8. Engage single target with coax	1	2	3	4	5
9. Adjust fire using re-engage technique	1	2	3	4	5

10. Engage multiple targets with main gun	1	2	3	4	5
11. Engage target: emergency degraded mode	1	2	3	4	5
12. Engage targets from gunner's position	1	2	3	4	5
13. Acquire targets: Evaluate situation	1	2	3	4	5

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