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

Research Report 1570

Soldier Performance Using a Part-Task Gunnery Device (TOPGUN) and Its Effects on Institutional-Conduct of Fire Trainer (I-COFT) Proficiency

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Fire Trainer (I-COFT) Proficiency**

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FOREWORD

The U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) Field Unit at Fort Knox conducts research on armor training and simulation and human performance with armor weapon systems. This research examined soldier performance on TOPGUN, a part-task gunnery training device, and the effects of such training on Institutional-Conduct of Fire Trainer (I-COFT) proficiency. The TOPGUN device was developed through the cooperative efforts of the Defense Advanced Research Projects Agency (DARPA) and ARI. It is intended for use by Armor crewmen, primarily in recreational dayrooms and leisure areas, and enables practice of basic tank gunnery skills.

Tank gunnery skills proficiency on TOPGUN, as defined by measures of accuracy and speed, was examined under varying experimental conditions in a series of three experiments. The major findings of this research were (a) experienced and inexperienced soldiers learned basic tank gunnery skills as demonstrated by performance improvements on TOPGUN; (b) device-based performance improvements were not significantly different using either recreational (free-play) or formal (structured) training for experienced and inexperienced soldiers; (c) gunnery skills by qualified tank crewmen improved significantly from pretest to posttest, however, group differences were not detected; and (d) the overall attitude of soldiers toward the TOPGUN device was very positive.

The research was conducted by the ARI Fort Knox Field Unit, Fort Knox, Kentucky. The results of the research were presented to the Director, Defense Advanced Research Projects Agency (DARPA), and the Director, Directorate of Training and Doctrine (DOTD), U.S. Army Armor Center (USAARMC).



EDGAR M. JOHNSON
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The authors are indebted to several ARI Fort Knox Field Unit staff members who contributed to this research. The assistance of the R&D Coordinator, MAJ Milton E. Koger, was essential in arranging soldier support and providing conduct-of-fire classroom instructions to inexperienced armor research participants. SSG Mark IV Dean provided assistance that was particularly critical in programming the formal scenarios used for TOPGUN training and testing. Mr. Merle Allen deserves special recognition for his diligence and accuracy in both the operation and maintenance of the TOPGUN devices and the administration of training and testing during conduct of the research. Dr. David W. Bessemer's advisory assistance during the design and statistical analysis of the data was very helpful.

SOLDIER TRAINING USING A PART-TASK GUNNERY DEVICE (TOPGUN) AND ITS EFFECTS ON INSTITUTIONAL-CONDUCT OF FIRE TRAINER (I-COFT) PROFICIENCY

EXECUTIVE SUMMARY

Requirement:

The advanced technological sophistication of the M1 Abrams tank weapons system demands an aggressive training strategy that will ensure tank crews can effectively destroy the enemy when using the weapons system in combat. Gunnery training that relies heavily on the expenditure of live ammunition to achieve required proficiency levels can no longer be justified. To help overcome this problem, the Army has recognized the requirement for the development of tank gunnery training devices and simulation. Such devices have the potential to train tank gunners and avoid the high vehicle-based training costs associated with the increased amounts of training needed to attain and sustain high levels of gunnery proficiency. The present research investigates soldier performance on TOPGUN, a part-task gunnery trainer, and its effects on Institutional-Conduct of Fire Trainer (I-COFT) proficiency.

Procedure:

Three separate experiments were conducted, with the first two experiments combined for purposes of analysis. In the first experiment, 23 Cavalry Scout (MOS 19D) soldiers waiting to attend the Advanced Noncommissioned Officer Course (ANCOC) were randomly assigned to three groups: recreational (REC), formal (FORM), or no training group (NTG). In the second experiment, 24 armor officers waiting to attend the Armor Officer Basic (AOB) course were randomly assigned to the three treatment groups. Soldiers in both experiments were given 15 minutes of M1 conduct-of-fire classroom instruction, 10 minutes of TOPGUN familiarization and hands-on practice, and pretested on TOPGUN. Soldiers in the FORM and REC groups were given 2 hours of device training, after which all soldiers were posttested on TOPGUN. In the third experiment, 36 qualified tank crewmen were pretested on I-COFT and, following 10 minutes of TOPGUN familiarization and hands-on practice, pretested on TOPGUN. An equal number of soldiers were assigned to each of the three groups based on a crude measure of performance derived from the I-COFT and TOPGUN pretest scores combined. After soldiers in the two training groups trained on TOPGUN for about 9 hours over 4 consecutive days, all soldiers were posttested on the I-COFT and TOPGUN. In each experiment, soldier tank gunnery proficiency was determined by six measures of gunnery accuracy and speed of target engagement.

Findings:

In Experiments 1 and 2 combined, soldier performance scores improved significantly from TOPGUN pretest to posttest on all six performance measures. However, no significant differences were detected among the three groups. In Experiment 3, soldier performance scores also improved significantly from TOPGUN pretest to posttest on all six performance measures. Group differences were found for five of the performance measures, with the combined effects of the two training groups performing significantly better than the no training group. No group differences were found on the posttest scores using the pretest scores as covariates. Significant improvements also were found in soldiers' scores from I-COFT pretest to posttest for five of the performance measures. However, significant group differences were not detected among the three groups. No significant differences in TOPGUN or I-COFT performance scores were found in the three experiments for soldiers who were trained using a free-play versus a structured training strategy. The inability to detect significant group differences in Experiments 1 and 2 combined may be attributed to ceiling effects found with some of the TOPGUN exercises and the fact that the no training group showed an increase in performance from pretest to posttest that was probably due to the practice effects of the pretest exercises. These problems, along with a reduced sample size compared to Experiments 1 and 2 combined, also existed with Experiment 3. The overall attitudes and experiences of soldiers who trained on the TOPGUN device were positive. They enjoyed training on the device and indicated that such training would make them better gunners.

Utilization of Findings:

The findings of this research were presented to the Director, Defense Advanced Research Projects Agency (DARPA), and the Director, Directorate of Training and Doctrine (DOTD), U.S. Army Armor Center (USAARMC). The results contribute supportive data to U.S. Army agencies concerned with soldier performance and transfer using a reduced fidelity, part-task gunnery training device. They also provide U.S. Army Active and Reserve Component units scheduled to receive TOPGUN with a basis for developing quality tank gunnery training within their limited training time and resource constraints.

SOLDIER PERFORMANCE USING A PART-TASK GUNNERY DEVICE (TOPGUN) AND
ITS EFFECTS ON INSTITUTIONAL-CONDUCT OF FIRE TRAINER (I-COFT)
PROFICIENCY

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SOLDIER PERFORMANCE USING A PART-TASK GUNNERY DEVICE (TOPGUN)
AND ITS EFFECTS ON INSTITUTIONAL-CONDUCT OF FIRE TRAINER
(I-COFT) PROFICIENCY

Introduction

The advanced technological sophistication of the M1 Abrams tank weapons system demands an aggressive training strategy that will ensure tank crews can effectively destroy the enemy when using the full capability of the weapons system in combat. The goal of tank gunnery training is, therefore, to close the gap between the increased combat effectiveness provided by the weapons system and the tank gunnery proficiency levels required to exploit this combat effectiveness.

Meeting the required levels of tank gunnery proficiency are extremely difficult, however, because of the high costs of tank ammunition and the limited availability of equipment and live-fire ranges. Gunnery training that relies heavily on the expenditure of live ammunition to achieve required proficiency levels can no longer be justified (U.S. Army Armor School, 1981). To help overcome this problem, the Army has recognized the requirement for development of tank gunnery training devices and simulation (Department of the Army, 1984; U.S. Army Armor Center, 1984). Such devices have the potential to train tank gunners in the domain of tank gunnery tasks, provide detailed performance feedback, and allow training remediation until the gunnery tasks are mastered. They also permit training of gunnery tasks that are unsafe or impractical to train under a vehicle-based, full-caliber strategy.

The current device-based training strategy calls for the efficient integration of fielded and programmed training devices, simulators, and simulations that affect Armor training (U.S. Army Armor School, 1988). The overall goal is to achieve an efficient use of training dollars by avoiding the high vehicle-based costs associated with the increased amounts of training needed to attain and sustain high levels of tank gunnery proficiency. To meet this goal, whole-task, high-fidelity gunnery devices must achieve the same or higher degree of training proficiency as provided by vehicle-based training. Likewise, part-task gunnery devices must lead to improved performance on whole-task trainers.

Currently, gunnery simulators range in cost and complexity from a \$17,500 part-task, table-top trainer that uses videodisk to present filmed target scenes [e.g., Videodisc Interactive Gunnery Simulator (VIGS)] to a \$1,900,000 high-fidelity, whole-task gunnery trainer that allows tank commander/gunner teams to fire a matrix of 685 increasingly difficult engagement exercises [(e.g., Unit-Conduct of Fire Trainer (U-COFT))] (Training Device Information Papers, 1990). Obviously, whole-task trainers are too costly to provide in the numbers needed by the armor force to train individual skills. It's also inefficient to use such

devices to train only part of the skill requirements. Part-task trainers requiring relatively low cost, concentrating only on the skills that must be trained, and using only the crew member involved might provide an efficient hierarchy for gunnery skill training and sustainment.

The present research investigates soldier performance on a part-task gunnery device called TOPGUN and its effects on I-COFT proficiency. TOPGUN (see Figure 1) was developed through the cooperative efforts of the Defense Advanced Research Projects Agency (DARPA) and the Army Research Institute (ARI). It is intended for use by Armor crewmen in practicing basic gunnery skills, primarily in recreational dayrooms and leisure areas. TOPGUN is manufactured by NKH, Incorporated (1986) and is modeled on a prototype device called BATTLESIGHT developed by Level II, Incorporated (1985) for M60A1 tank gunnery. The TOPGUN device used in this research cost about \$9,000 and can be used for both M60A3 and M1 tank gunnery training (NKH, Inc., personal communications, May 16, 1990).

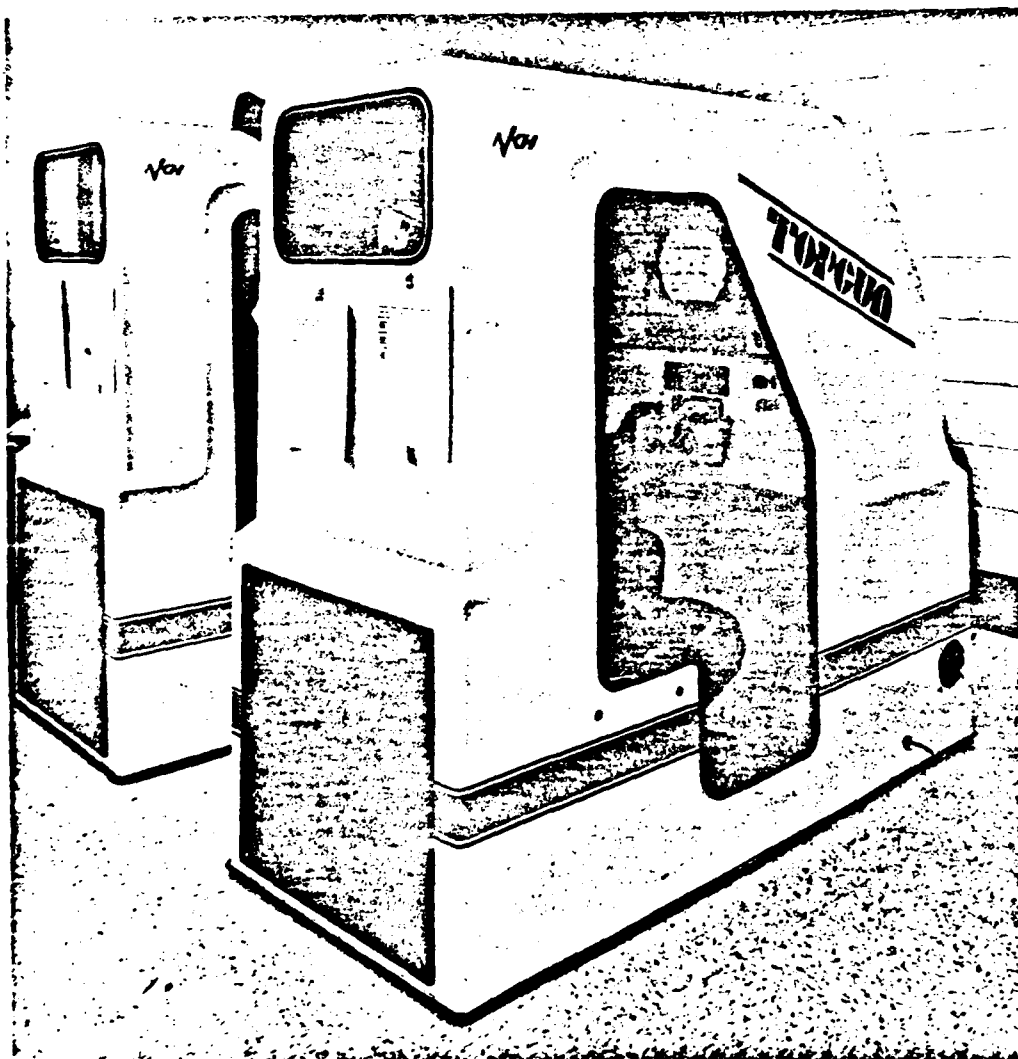


Figure 1. TOPGUN

TOPGUN features the intrinsically motivating aspect of most computer video games: challenge, fantasy and curiosity. It also appears to satisfy the instructional purpose of a tank gunnery device. Soldiers who have volunteered to use the device appear to enjoy using it to practice gunnery for self-satisfaction and without expectation of external reward. Such participation to voluntarily practice gunnery on TOPGUN could lead to increased gunnery performance on whole-task gunnery trainers like U-COFT. If so, substantial time and money could be saved by reducing the amount of training time required to become proficient on UCOFT.

TOPGUN Characteristics and Capabilities

The TOPGUN device (see Figure 2) consists of an enclosed gunner's station equipped with (a) the gunner's control handles (cadillacs) for traversing the turret, elevating or depressing the main gun, laser-ranging to targets, and firing; (b) the switches and controls for selecting weapon (main gun, coax), sight (primary, secondary, thermal), sight polarity (black hot, white hot), and sight magnification (3x or 10x); (c) a cathode-ray tube (CRT) for displaying computer generated enemy tank targets (T-72 tank), battlefield terrain features, (trees, houses, rubble, etc.), and sight reticles; (d) an automated tank commander for issuing fire commands and slewing the turret for initial target acquisition; and (e) a three-channel, computer-controlled audio system for providing realistic battle sounds and tank commander and loader voice commands.

An amplifying data display area is located to the right of the CRT and provides two types of displays: a wide field of view (WFOV), and game data. The WFOV is designed to show the player the gross location and type of active threats (red dot for most dangerous threat, yellow dot for dangerous, and blue dot for least dangerous) and corresponds to the gunner's unity window. The game data area directly below the WFOV shows the status of the training session (score, ammunition remaining, elapsed stage and game time, gun azimuth and elevation angles, range to target, and gun status).

TOPGUN also contains a Performance Measurement System (PMS) that consists of two major subsystems: data acquisition subsystem (DAS), and analysis subsystem (AS). The primary function of the DAS is to acquire real time data reflecting subject performance for offline evaluation using the AS. Its two other functions are to provide a means to load formal training scenarios into TOPGUN and a mechanism for loading software updates into TOPGUN. The AS consists of a small, stand-alone AST Premium/386 computer that uses commercial off-the-shelf software and custom application software. Used with the TOPGUN device, it provides for three major functions. It permits the creation of formal training scenarios, the analysis and evaluation of the data collected by the DAS, and general computational, programming and analysis.

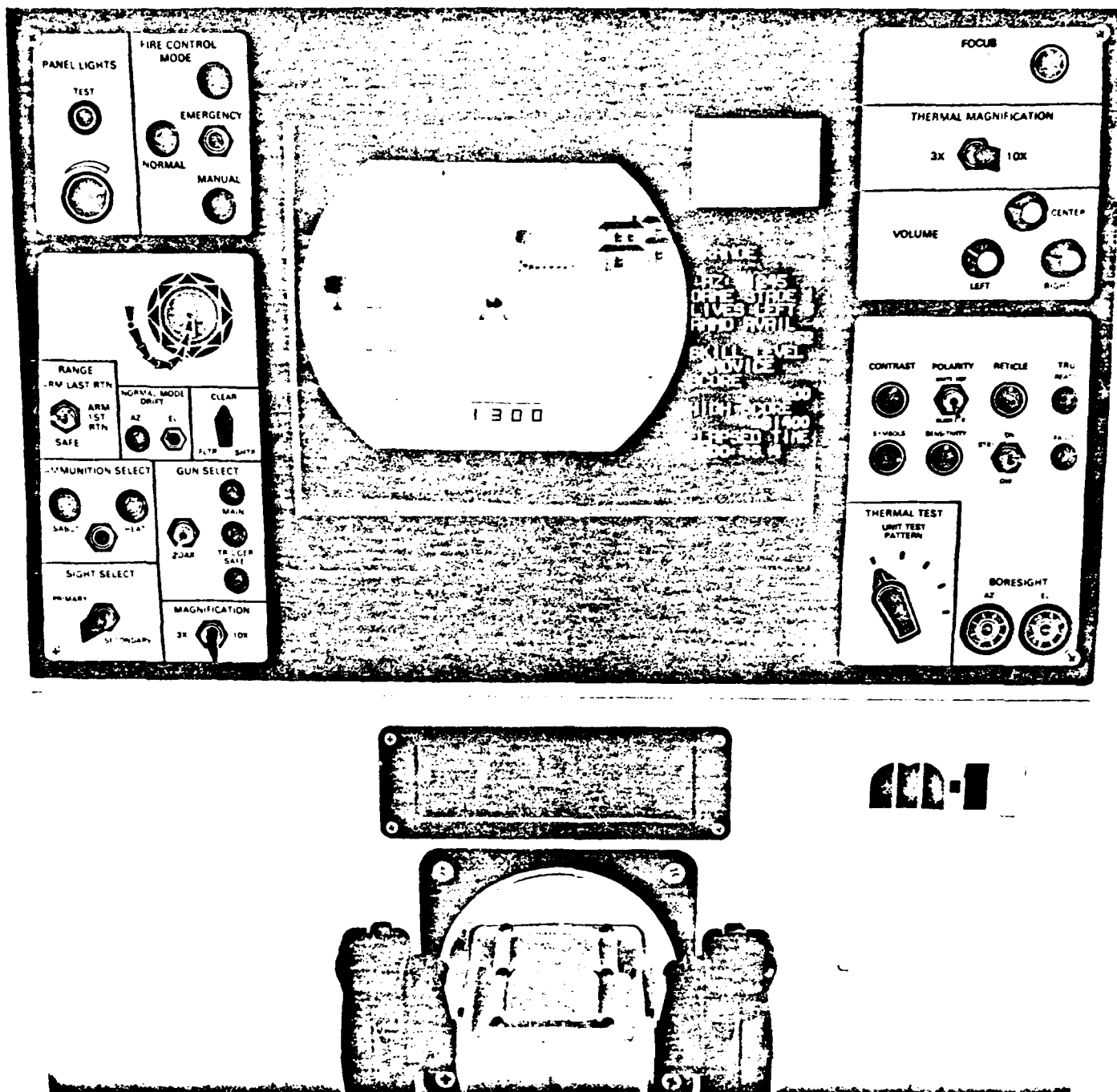


Figure 2. TOPGUN tank gunner's controls and displays

The latest software developed for TOPGUN (Software Release Version 1.49 and 1.50) contains several field modifiable initialization parameters (FMIPs). FMIPs can be replaced to meet the particular requirements of a formal test or training program and then restored to their original default values. The FMIP for kill zone, for example, is set at 100% but can be changed in 10% increments. The kill zone is represented by a small rectangle corresponding to a "tank box" totally surrounding a threat T-72 tank. At 100%, the threat tank is hit if the impact point of the projectile has any points in common with the tank box. At 10%, the projectile must be at or near the center of the target's visible mass in order to obtain a hit. Probabilistic hit detection algorithms developed for TOPGUN determine if a threat tank is actually "killed" by the player's round (TOPGUN Design Specifications, 1986).

TOPGUN Operation. TOPGUN can be used for either recreational (free-play) or formal (structured) training. Free-play training is governed by the device's computer and is probabilistic in nature. The intent is to provide the gunner with random, computer-generated target engagement scenarios that will challenge his skill level and not be repetitive. Formal training is structured and deterministic. The background and threat visuals of target scenarios are predefined by a trainer or research analyst and controlled by means of the software-based PMS. The PMS allows gunner performance data (e.g., hits, hit time, opening time, gun laying errors) to be recorded on a floppy diskette for offline computer analyses. It also provides immediate feedback at the end of a game stage in the form of a single points "score". This score is a weighted value of several factors such as the number of targets destroyed, the time required for destruction, the number of rounds of ammunition required for destruction, etc.

After entering either the recreational or formal mode of operation, the system software interacts with the player to establish the Player Experience Level (PEL); Novice, Qualified, or Expert. Additionally, play is divided into a series of three stages or difficulty levels. Transition from one difficulty level to another is based on player performance and elapsed time. Based on the player's performance during the preceding stage, the PEL will be retained, lowered one level or increased to the next higher level. Once a player's PEL is established, one or more computer generated tanks (targets) will randomly appear on the CRT display. The tanks can be stationary or moving behind and around cultural objects such as houses and trees, and can assume full or partial defilade positions. When the tanks appear, a (pseudo) tank commander will issue a fire command and slew the turret/gun in the vicinity of the nearest target. The player is to then acquire the target, determine range using the laser rangefinder, and fire until the target is destroyed. If the target is not destroyed within a fixed time period, destruction of the player's vehicle is simulated. System parameters are used to determine the number of vehicles (lives) a player will have

available before play is terminated. The game ends once the player exhausts the supply of vehicles (lives) or allocated ammunition. Performance statistics are then calculated and displayed to the player.

I-COFT Characteristics and Capabilities

The Institutional-Conduct of Fire Trainer (I-COFT) is a high fidelity gunnery trainer designed for training gunners or tank commander/gunner pairs to perform the individual and crew gunnery skills required during tank gunnery engagements. The I-COFT is a special configuration of the Unit-Conduct of Fire Trainer (U-COFT) that consists of four U-COFT substations linked to an Ethernet controller to permit records transfer. The I-COFT and U-COFT are virtually identical with the exception that the I-COFT includes software options that permit training of either the tank commander or gunner separately or a tank commander and gunner combination as in the U-COFT. By means of an automated tank commander, I-COFT tests can be used to standardize the contributions of the tank commander in tank gunnery engagements leaving only gunner performance.

Figure 3 depicts the major subsystems constituting the I-COFT. These subsystems include an instructor/operator (I/O) station, an enclosed crew station, a special purpose computer, and a general purpose computer (General Electric Company, 1985). The I/O station includes separate monitors for real-time monitoring of the performances of the gunner (and commander), an instructor's control terminal, and a printer for recording the crew's performance. The gunner's station (see Figure 4) contains the Gunner's Primary Sight (GPS), the Gunner's Auxiliary Sight (GAS), the Thermal Imaging System (TIS) Control Panel, and nearly all the switches and controls used by the gunner for gunnery in the M1 tank.

I-COFT Operation. Upon entering the I-COFT, the gunner is presented with a scenario describing the operational status of the vehicle and then directed by the I/O to place selected fire control switches in their proper position. Once the I/O and gunner are ready to begin the exercise, a target is presented by means of a prerecorded fire command issued by a pseudo tank commander. In response to the fire command, the gunner moves from a turret-down to a hull-down firing position, acquires the target, lays on target center of visible mass and tracks (if target is moving), determines range using the laser rangefinder, and fires. If the target is missed and time permits, the gunner reengages (relays, releases, and fires) the target. When the target is hit or when the gunner's tank is exposed for more than 18 s, the gunner's tank returns to a turret-down position to await the next target engagement. After all ten engagements are presented within an exercise, a computer printout of the gunner's performance is produced by the I/O who then critiques the gunner's performance.

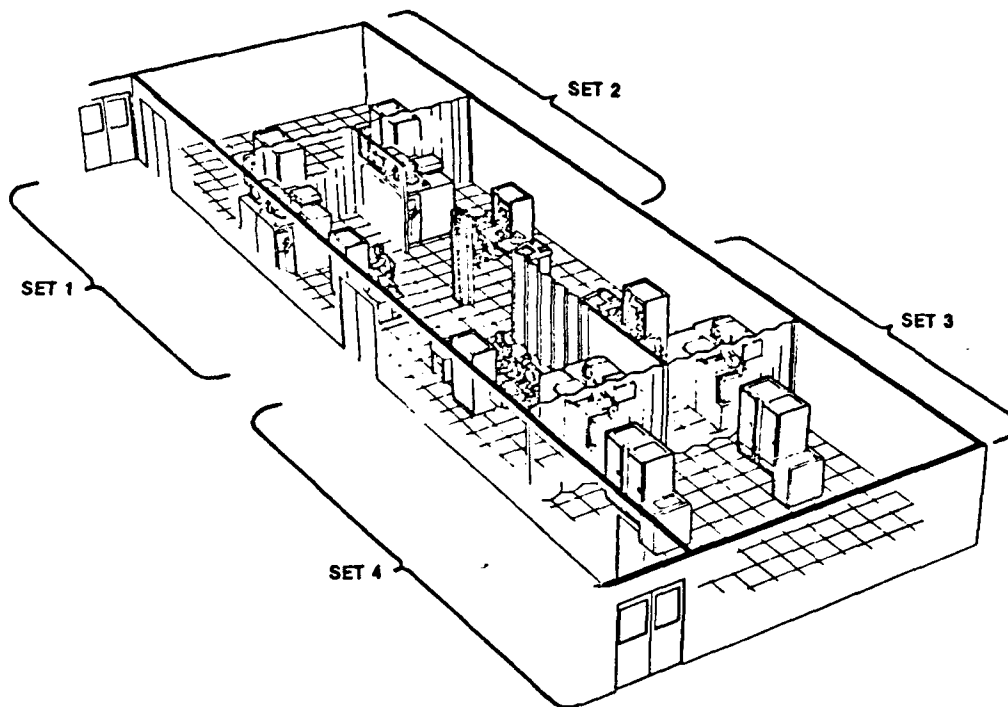


Figure 3. Institutional-Conduct of Fire Trainer (I-COFT) subsystems

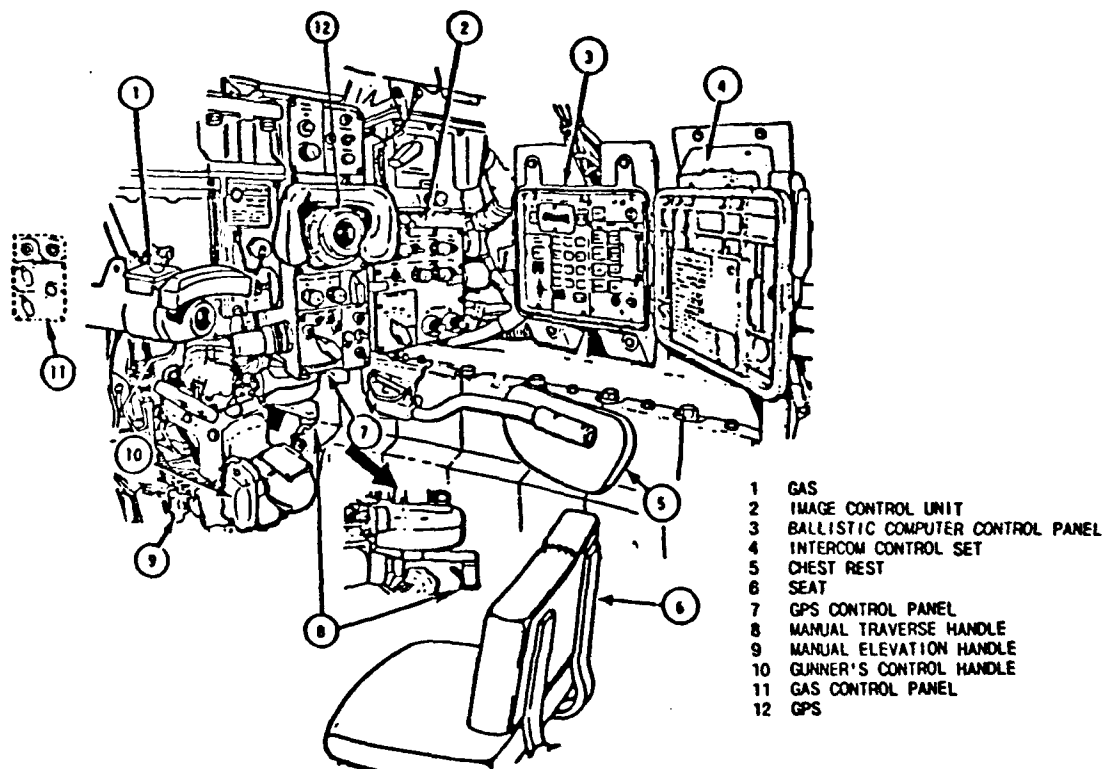


Figure 4. Institutional-Conduct of Fire Trainer (I-COFT) tank gunner's station

TOPGUN and I-COFT Comparison

TOPGUN and I-COFT are similar by comparison in that they both permit the gunner to acquire, track, and fire at moving and stationary targets using simulated fire control system controls and switches. They differ noticeably, however, in the kinds of engagements available, the weapons simulated for firing those engagements, and the gunnery procedures trained (manipulating correct switches in their proper sequence). The I-COFT simulates firing at targets moving from a turret-down to a hull-down stationary firing position, firing at targets from a moving vehicle, and several various degraded mode gunnery engagements. The TOPGUN device only simulates firing at main gun targets from a stationary vehicle and firing degraded mode using the GAS. The I-COFT also allows the gunner to select ammunition, fire at targets other than tanks (e.g., trucks, helicopters), fire the coaxial machine gun (COAX), and train the gunner and tank commander as a team. TOPGUN does not allow these functions or require the gunner to follow the tank gunnery procedures performed in an actual M1 tank.

While I-COFT has many more capabilities than TOPGUN, it also costs over two-hundred times as much. If gunnery performance could be improved as a result of training on TOPGUN and this improvement were reflected in I-COFT performance, then training costs could be reduced substantially.

Previous Research

Training Device Effectiveness. Previous research has been conducted to determine the effectiveness of TOPGUN training and other part-task gunnery training devices and their ability to improve gunner performance. ARI research scientists at the Fort Knox Field Unit conducted a series of three experiments using the prototype TOPGUN device, BATTLESIGHT, (Abel, 1986). In the first two experiments, the relationship between gunnery performance and level of experience was examined using experienced (tank commanders and gunners) and inexperienced (drivers and loaders) soldiers as gunners. The results of the experiments indicated a significant improvement in number of hits and number of first round hits over practice trials with no difference between groups. In the third experiment, soldiers' accuracy and speed were examined over three trials under two different game formats (standard and equally distributing lives and ammunition into three separate games) and two different target kill zones (100% of rectangle surrounding the threat tank and 50% of the rectangle). The game formats were (a) the standard video game with three lives and 60 rounds of ammunition, and (b) a revised game format with equal distribution of the three lives and 60 rounds of ammunition into three separate games. The results of the experiment indicated a significant difference in accuracy between the standard kill zone and reduced kill zone groups, with the reduced kill zone groups being less accurate overall. For the revised video game group, soldiers' accuracy improved. No

improvement was indicated for groups that used the standard game format. Improvement was found for all groups in the average time to fire.

The finding by Abel (1986) that small, more difficult kill zones resulted in faster but less accurate performance is consistent with the results of an evaluation of the Videodisc Gunnery Simulator (VIGS), the MK60 Tank Gunnery Simulator. Hoffman and Melching (1984) found that soldiers trained on the device learned to emphasize speed at the apparent expense of tracking precision. Similar findings were reported by Boldovici (1984) with soldiers completing One Station Unit Training (OSUT) in armor. Soldiers trained using VIGS, as compared with soldiers who received conventional tank gunnery training, had faster opening times and fewer procedural errors but were not significantly more accurate as determined by live-fire or dry-fire performance measures.

In research conducted to evaluate the relationship between two tank gunnery trainers, the VIGS and the Unit-Conduct of Fire Trainer (U-COFT) (Witmer, 1986), it was found that inexperienced soldiers learned to perform device-based gunnery skills as demonstrated by significant performance improvements on each device. Significant correlations between the U-COFT and VIGS performances also were found to suggest that performance on either device can be used to predict performance on the other. Graham (1986) has shown that gunnery performances can be reliably measured on the U-COFT, obtaining test-retest reliabilities ranging from .72 to .87 on six of nine gunnery performance measures. Despite the demonstrated predictive relationship, however, prior training on the VIGS device did not result in increased performance levels on the U-COFT. Neither did prior training on the U-COFT lead to improved performance on VIGS. These results failed to support the notion that skills learned on one training device lead to improved performance on another device. As reported by Witmer, the lack of transfer from VIGS to the U-COFT and vice versa may be accounted for by insufficient practice on the two devices during training. Soldiers received two replications of 27 target engagement trials for a total of 54 engagements.

In recent research conducted by researchers at the University of Central Florida (Turnage & Bliss, 1989), three gunnery trainers (TOPGUN, VIGS and I-COFT) were examined to determine (a) learning transfer over repeated trials, (b) pretraining sequence for maximum performance effects, and (c) the degree of gunnery skills transfer between two part-task gunnery trainers and the full-fidelity simulator (I-COFT). Criterion performances on the I-COFT were analyzed for two pretraining groups (TOPGUN first then VIGS, VIGS first then TOPGUN) and a no training control group. The training groups consisted of 20 students each, with each group receiving two multiple-mission engagement trials over four consecutive days before I-COFT transfer. In this research, TOPGUN and VIGS training consisted of two 36-target trials per day for two days for a total of 144

engagements per device. The results of the research indicated that: (a) performance improved at equal rates during TOPGUN and VIGS training, (b) there was significant transfer between most TOPGUN and VIGS performances with no apparent superiority of either device, (c) except for speed measures, TOPGUN and VIGS training transferred to I-COFT, and (d) there was no apparent difference between the TOPGUN-VIGS or VIGS-TOPGUN sequences of training.

In more recent research conducted by ARI scientists at Boise, Idaho (Hart, Hagman and Bowne, 1990), the effects of TOPGUN training on tank gunnery performance using the U-COFT were examined. The performance of three groups of 16 Reserve Component soldiers was compared using a transfer-of-training design. Groups differed only on number of training sessions (0, 1 or 3) performed before completing a single testing session on U-COFT. In this research, TOPGUN and U-COFT sessions each consisted of 40 single-target engagements. The results of the research indicated that: (a) accuracy and speed of stationary and moving targets engagements improved across the three sessions of TOPGUN training, (b) groups that received training on TOPGUN displayed better accuracy on U-COFT than the control group, but only on stationary engagements, and (c) TOPGUN performance was a reliable predictor of U-COFT performance with greater correlations found for speed than for accuracy.

The reported capability of using VIGS and TOPGUN to provide effective tank gunnery training is consistent with past research on gunnery training devices (e.g., Abel, 1986; Witmer, 1986). The fact that specific gunnery skills learned on the two part-task gunnery trainers led to improved performance on I-COFT is not surprising because the researchers adhered to guidelines for reduction of sources of errors in transfer experiments with military training devices (Boldovici & Sabat, 1985). As listed by Boldovici and Sabat, the most common sources of error in recent evaluations of training devices include: (a) small numbers of subjects are used in the evaluation, (b) subjects are not assigned randomly to groups, (c) groups are treated differently in respects other than those under specific investigations, and (d) the criteria used to evaluate training devices are often not reliable.

Training Strategy. The most frequently used strategy in training tank gunnery is to implement a hierarchical approach, proceeding from simple or easy engagement exercises to complex or difficult engagements. This approach is evident in the M1 Tank Combat Tables (FM 17-12-1, 1986) and the M1 U-COFT Device Support Package (ST 17-12-7-1, 1990). Advocates of this approach stress the importance of allowing skills to develop gradually, permitting gunner to master the easier tasks before attempting the more difficult tasks. It also has been argued that an easy-to-difficult transfer sequence allows for the development of high performance standards (Holding, 1962; Holding, 1965). The basic assumption is that high standards, or expectations of good

results, are carried over to the more difficult transfer task, thus promoting better performance following transfer.

However, convincing arguments also can be made in favor of placing greater emphasis on the use of more difficult engagement exercises during training. One argument is based on the principle of "inclusion" (Briggs, 1969; Holding, 1962,; Holding 1965). The principle states that if the training task includes most or all of the requirements present in a subsequent transfer task, then transfer performance will be high; but if this inclusion is not present, then transfer performance will be low. By implication, high positive transfer should result following training on more difficult target engagements.

Another argument in favor of concentrating training on the more difficult engagements is based on schema theories (Bartlett, 1932; Schmidt, 1975). According to these theories, skills are mastered by learning "schemas", or plans for responding, not specific responses. Schema theories predict that stronger schemas will be produced and better performance will result when practice is varied. This is because a better plan for responding can be formed after a learner has been exposed to a variety of instances of a response class. If schema theories are correct, practice that focuses on the more difficult target engagements should result in better overall gunnery performance than practice distributed across an easier-to-difficult task approach.

In light of the research that has been conducted, questions still remain regarding the training effectiveness and transfer of TOPGUN device performance as well as the training strategy that is most conducive to improving tank gunnery performance. For example, in the Trunage and Bliss research the participants were college students rather than the intended population of military users from the U.S. Army Active and Reserve Components. The students also were paid for their participation, with the amount of money received based on whether they signed-up to be in the training groups or the control group. Additionally, the students who were trained on TOPGUN had their performance critiqued by individual instructors following each training session. In the Hart, Hagman and Browne research, the users were inexperienced tank gunners from the Idaho Army National Guard. Half of them held the 19E Military Occupation Specialty (MOS), but were not tank gunners. The other half had non-19E MOSs and no tank gunnery experience. The gunnery training provided on TOPGUN followed a formal, easy-to-difficult task approach and consisted of using only the auxiliary sight (M105D telescope) to engage targets. No training was provided using the free-play mode of training on TOPGUN which focuses on the more difficult target engagements.

Purpose of the Research

The main objective of this research was to assess soldier performance using TOPGUN following a recreational or formal

training approach and the effects of such training on I-COFT proficiency. The results of the research were expected to provide answers to the following questions:

1. Does gunnery performance on TOPGUN improve as a result of training on the device?
2. Does the type of training on TOPGUN (free-play versus structured) make a difference in gunnery improvement?
3. Does training on TOPGUN lead to increased performance on I-COFT?
4. Does the type of TOPGUN training make a difference on I-COFT performance?
5. Do soldiers enjoy training on TOPGUN and how do they feel about the device?

Hypotheses

The skills expected to be learned on TOPGUN include: (a) acquiring targets, (b) laying the sight reticle on target, (c) tracking moving targets, (d) using the laser rangefinder to determine target range, and (e) firing on targets in response to fire commands. Improvements in both accuracy and speed of engaging targets should occur as a function of learning these skills. Similarities between the TOPGUN and I-COFT devices suggest that tank gunnery skills learned on TOPGUN should lead to improved performance on I-COFT. Based on the principle of inclusion and schema theory, training on TOPGUN using a free-play approach should yield greater improvement and transfer.

Method

To address the hypotheses and provide answers to the research questions formulated, three separate but interrelated experiments were conducted. The first two experiments differed in the type of soldiers tested. Because the sample size in both of these experiments was small and analyses showed no difference in performance between these two groups of subjects, the first two experiments were combined to increase the power of statistical tests and better determine the effects of TOPGUN training on gunnery performance. Post hoc comparison of the means and standard deviations on the six performance measures for the two experiments indicated the data could be combined for analysis.

The procedures used to conduct the three experiments were quite similar. Therefore, the experimental procedures are reported collectively rather than separately. To help the reader understand the procedures used in each experiment, a summary of the experimental treatments is presented in Tables 1 and 2.

Table 1

Summary of Experimental Treatments for Soldiers in Experiments 1 and 2 Combined

Experiment 1 (23 19D ANCOC Soldiers) Experiment 2 (24 Pre-AOB Soldiers)					
Treatment Group	TOPGUN Classroom Instruction	TOPGUN Familiarization	TOPGUN Pretest	TOPGUN Training	TOPGUN Posttest
REC	15 min	10 min	15 min 30 tgts	2 hr (free-play)	15 min 30 tgts
FORM	15 min	10 min	15 min 30 tgts	2 hr (structured)	15 min 30 tgts
NTG	15 min	10 min	15 min 30 tgts	None	15 min 30 tgts

Table 2

Summary of Experimental Treatments for Soldiers in Experiment 3

Experiment 3 (36 19K Armor Crewmen)						
Treatment Group	I-COFT Pretest	TOPGUN Familiarization	TOPGUN Pretest	TOPGUN Training	I-COFT Post-test	TOPGUN Post-test
FORM	1 hr 40 tgts	10 min	1 hr 84 tgts	9 hr (free-play)	1 hr 40 tgts	1 hr 84 tgts
REC	1 hr 40 tgts	10 min	1 hr 84 tgts	9 hr (structured)	1 hr 40 tgts	1 hr 84 tgts
NTG	1 hr 40 tgts	10 min	1 hr 84 tgts	None	1 hr 40 tgts	1 hr 84 tgts

Subjects

A total of 83 soldiers from Ft. Knox, Kentucky, representing different levels of education and tank gunnery experience, participated in the three experiments. Soldiers in the first experiment were 23 senior noncommissioned officers (NCOs) who held the MOS of Cavalry Scout (19D) and were waiting to attend the Advanced Noncommissioned Officer Course (ANCOC). Soldiers in the second experiment were 24 recently commissioned officers who were waiting to attend the Armor Officer Basic (AOB) course. Soldiers in the third experiment were 36 NCOs who were qualified as M1 Armor Crewman (MOS 19K).

Key Personnel and Functions

This research required the assistance of four civilian and two military research personnel. The four civilians and one of the military assistants operated the TOPGUN devices during the pre- and posttest administrations and during training. One of the military assistants helped to create the pre- and posttests and training scenarios. He also used the mainframe computer for general computational analysis and evaluation of the data collected by TOPGUN. The other military assistant prepared and presented a M1 Abrams conduct-of-fire training session for the soldiers. This classroom training explained and demonstrated the tank gunnery procedures required for engaging main gun targets with SABOT ammunition using the GPS, the Thermal Imaging System (TIS), and the GAS. All assistants used in this research were trained to perform the experimental procedures during a one-day training session.

Equipment and Materials

The primary equipment used to conduct the research was the TOPGUN device and the I-COFT. Both trainers were described earlier and are depicted in Figures 1-4. The materials developed for use with TOPGUN were: (a) one pre- and posttest computer program containing 30 main gun tank target engagements; (b) six pre- and posttest computer programs, each containing 84 main gun tank target engagements; and (c) one computer program for the formal training of gunners. The computer programs developed for TOPGUN testing and training (Kraemer & Dean, 1989) were based on target engagement formats developed for training novice gunners on TOPGUN (see Appendix A). They were created using TOPGUN PMS Software Release Version 1.49 and 1.50 (NKH, 1988) for scenario generation. The computer program used for recreational training of novice gunners was developed by NKH for use with TOPGUN (random presentation of tank target engagements). Other materials developed to conduct the experiments were: (a) general instructions to TOPGUN subjects (Appendix B); (b) a Soldier Background Information Questionnaire (Appendix C); (c) a Soldier Opinion Questionnaire (Appendix D); and (d) general instructions to I-COFT subjects (Appendix E).

Instruments

TOPGUN Pre- and Posttest. The pre- and posttests developed for use with TOPGUN were based on the target engagement formats developed for training novice gunners on each of nine tank gunnery training objectives (see Appendix A). The specific test engagements were identified by using a 3^3 factorial, 9×9 quasi-latin square design (Cochran & Cox, 1957). For the first two experiments, only 30 of the engagements identified at the highest level (Stage) of engagement difficulty were selected for the pre- and posttest. These engagements are shown by an asterisk (*) in Appendix A. The order in which the target engagements appear in the TOPGUN pre- and posttest is presented in Appendix F. For the third experiment, all the engagements identified were used to develop six alternate forms of the pre- and posttest. The target engagements for each alternate form of the TOPGUN pre- and posttest are presented in Appendix G.

Thirty target engagements were selected for the TOPGUN pre- and posttest in the first two experiments (see Appendix A). There were 18 single tank target engagements (nine stationary and nine moving targets) and six multiple (dual) target engagements (two with both targets stationary, two with one target stationary and the other moving, and two with both targets moving). The 18 single engagements contained one engagement from each of the three types of target movement conditions (flank, frontal, and oblique) for each of the three sights (GPS, TIS, GAS). The six multiple engagements contained at least one engagement from each of five types of target movement combinations (flank/flank, frontal/frontal, oblique/flank, oblique/frontal, oblique/oblique) for each of the three sights. For scoring purposes, the six multiple engagements were treated as 12 single target engagements. Approximately 15 min each were required to administer the pre- and posttest.

For the third experiment, each alternate pre- and posttest form consisted of 84 tank target engagements (see Appendix A and G). There were 27 single stationary tank target engagements, 27 single moving tank target engagements, and 15 multiple (dual) tank target engagements. The 54 single tank target test engagements (27 stationary, 27 moving) contained three engagements from each of the three types of target movement conditions (flank, frontal, oblique) for each of the three engagement difficulty levels (Stages I, II, III) and sights (GPS, TTS, GAS). The 15 multiple (dual) tank target test engagements contained one engagement from Stage I and two from Stages II and III to address each of five target movement combinations (flank/flank, frontal/frontal, oblique/flank, oblique/frontal, and oblique/oblique) and each of the three sights. For scoring purposes, the 15 multiple engagements were treated as 30 single target engagements. Approximately 60 min were required to administer each TOPGUN pre- and posttest.

As mentioned earlier, TOPGUN Software Release Version 1.49 and 1.50 contain FMIPs that can be replaced to meet the particular requirements of a formal test or training program. In the first two experiments, several FMIP default settings were modified for both the TOPGUN pre- and posttest and the training programs (see Appendix H). The FMIP for "immortality" was set so that the player could not be "killed" by the threat tank. The FMIPs for laser "burn-out" and "cooling-off" were disabled so that the player could fire at least two rounds at a target before it disappeared from the device field of view. The FMIP for "lethality" was set so that the player could shoot through buildings, trees and brushes. The FMIP for sight obscuration was increased so that the player could not see the flight of the round before impact. To simplify data analyses, the FMIP for the number of points given for first and second round hits using the GPS and GAS was set to 100 and 50, with zero points given for hits following a second round miss. Also, no penalty points were given if the player attempted to fire before "UP" was announced. To keep the number of rounds fired by the two training groups the same, the FMIP for the number of rounds that a player could fire was set at 54. This was consistent with the instructions given to players prior to training to fire only two rounds per target for the 27 target engagement scenario. The FMIPs that were disabled included: (a) the 30 s delay to move rounds to the ready rack, (b) "freezing" an engagement for player critique, (c) permitting a player to select his own experience level (novice, qualified, expert), and (d) allowing a player to engage targets without being laid-on by the tank commander.

In the third experiment, a few additional FMIPs were modified (see Appendix I). The FMIP for "kill zone" was modified for both the TOPGUN pre- and posttests and the training programs. For the pre- and posttests, the FMIP was changed to 50% of the target box rather than 100% so that the test engagements would be sufficiently difficult to distinguish the better players and eliminate performance ceiling effects. In both the REC and FORM training programs, players were required to successfully complete three iterations of the nine gunnery training objectives. The latter iterations were intended to sharpen the player's acquired gunnery skills by requiring a more exact positioning of the aiming point on the target's center of mass in order to obtain a hit. In order to accomplish this, the kill zone FMIP was modified to 80% and 50% for the second and third iterations. The remaining FMIPs that were modified all dealt with the percentage of multiple range returns that occur at near and far distances. These percentages are fixed at 10% and 35% respectively and are dependent on the maximum range to targets established in the training program.

I-COFT Pre- and Posttest. The I-COFT pre- and posttest consisted of four I-COFT exercises, each exercise containing 10 targets. These 40 target engagements contained 20 single moving targets using the GAS and 10 multiple engagements using the GPS. All target engagements began with the gunner moving from a

turret-down to a stationary hull-down position. The I-COFT exercises were selected based on comparable engagement possibilities using the TOPGUN device (i.e., target range and target movement from a defensive position using the main gun, SABOT ammunition, and the GPS or GAS). For scoring purposes, the ten multiple engagements were treated as 20 single engagements. Targets that were engaged using either HEAT ammunition or the coaxial 7.62 mm machine gun were excluded from the gunner's pre- and posttest scores. Approximately 60 min each were required to administer the I-COFT pre- and posttest. The main gun target engagements within each of the four I-COFT exercises are shown in Appendix J.

Soldier Background Information Questionnaire. Measures of experience and ability were obtained from the Soldier Background Information Questionnaire (see Appendix C) and included age, military grade, education level, military service time, armor service time, time on M1 tanks, time as an M1 gunner, time as an M1 U-COFT gunner, number of times M1 qualified on Tank Table VIII, TOPGUN experience, use of other gunnery training devices, and total time spent on all gunnery training devices.

Soldier Opinion Questionnaire. Measures of attitude and realism of TOPGUN for training were obtained from the Soldier Opinion Questionnaire (see Appendix D). The 16 items in Part 1 focused on how well the soldiers liked training on TOPGUN. A five-point Likert scale was used, and soldiers indicated their extent of agreement (1, strongly disagree; 5, strongly agree) with statements concerning the device. The 14 items in Part 2 focused on soldiers' perceived realism of the device. A five-point scale was used, and soldiers indicated their extent of agreement (1, not at all realistic; 5, extremely realistic) with statements about the device. Items negatively worded were reversed scored and mean ratings were computed.

This attitudinal component of the TOPGUN evaluation is considered very important because of plans to use the device in unit dayrooms or barracks where practice time on the device may be largely self-monitored. Positive attitudes toward TOPGUN would seem to increase the likelihood of voluntary practice.

Experimental Design

A 2 (Pretest, Posttest) x 3 (FORM, REC, NTG) mixed factorial design with repeated measures on the first factor was used to analyze the data for the three experiments. Soldiers in the FORM group were trained using a structured, easy-to-difficult approach while those in the REC group followed a free-play, more difficult approach. Soldiers in the NTG were in a no-training control condition and received only the pre- and posttests. This design permitted the examination of improvement in soldier tank gunnery performance from TOPGUN and I-COFT pretest to posttest, and differences in group training performance from TOPGUN and I-COFT pretest to posttest.

Operational Testing

TOPGUN Testing. In the first two experiments, the six research assistants were assigned to three of 18 TOPGUN devices. The devices were located side-by-side with a copy of the test switch settings used in conducting the test attached to the back of each device (see Appendix K). Each assistant tested three soldiers simultaneously. One research assistant was assigned to pretest and posttest all soldiers in the NTG while the other assistants were tasked to test-train-test soldiers in the two training groups. In the third experiment, the six research assistants were each assigned to test two soldiers simultaneously on two TOPGUN devices. The two devices were located side-by-side with a copy of the switch settings for the alternate form of the test attached to the back (see Appendix L).

To begin the test, the assistants moved the gun select switch on the devices from COAX to MAIN GUN. This allowed the device to present the target engagements programed for the test. After a fixed number of target engagements, the assistants placed the sight switches into their required positions. This was done to ensure that each gunner performed the same number and type of target engagements. When the gunner was required to use the GPS to engage targets, the sight select switch was set to GPS, the gun select switch to MAIN GUN, the ammunition select switch to SABOT, and the GPS sight magnification select switch to 10 X. When required to engage targets using the TIS, the sight select switch was changed to TIS and the TIS sight magnification select switch set to 10 X. The use of BLACK HOT or WHITE HOT polarity was left up to individual gunners. When required to use the GAS to engage targets, the sight select switch was changed to GAS. A 30 s time delay was programed in the test to allow adequate time for the assistants to change the sight switch settings.

In the first two experiments, soldiers in the FORM and REC training groups were given a 10 min break following the TOPGUN pretest and then trained on the device. Soldiers in the NTG were released to their unit with instructions to return 3 hr later for a posttest. In the third experiment, soldiers in all three groups were pretested on I-COFT and TOPGUN and told that they would be notified by their unit when to return for training or testing. The amount of time between pretesting and the start of training was about 2 days. On completion of TOPGUN training, all soldiers were posttested on the I-COFT and TOPGUN. In addition, soldiers in the two training groups were administered a Soldier Opinion Questionnaire (see Appendix D).

I-COFT Testing. I-COFT testing was conducted in the third experiment using six experienced I/Os who operate the devices to train soldiers at Fort Knox. The I/Os were given a brief overview of the research, a copy of the four exercises to be performed by the gunners on I-COFT, and specific instructions on how to conduct the testing. The I/O's were asked to provide the experimenters with a hard copy of the soldier's performance after

each exercise. Aside from helping the soldiers use the I-COFT, the I/Os were instructed not to assist or provide any form of tank gunnery performance feedback either during or after the test. Because of conflicting schedules, the I/Os were randomly distributed across treatment conditions. The I-COFT instructions are shown in Appendix E.

To begin the I-COFT test, general instructions describing the purpose of the research and the experimental procedures were read to the soldiers (see Appendix E). After a brief question and answer period, the soldiers were paired with an I/O and seated in the I-COFT gunner station. After soldiers completed the I-COFT test, they were instructed to report to the TOPGUN test site. Except for general research instructions and directions to the TOPGUN site, the I-COFT posttesting sequence was the same.

Operational Training

TOPGUN Training. Before soldiers in the two training groups arrived for training, the TOPGUN devices were prepared for either recreational or formal training. When the soldiers arrived they were immediately paired with the research assistants and seated in individual TOPGUN devices. As part of their pretraining instructions, the soldiers were told not to fire more than two rounds at a target and not to traverse the turret when a target was destroyed or disappeared from the display area. Once the soldiers indicated they were ready for training, the assistants moved the gun select switch from COAX to MAIN GUN to present the target engagements.

In the first two experiments, TOPGUN training consisted of training on seven of nine main gun tank gunnery objectives (see Appendix B). For the first three gunnery objectives, the gunners were presented with 27 single stationary target engagements using the GPS, TIS, and GAS. For the next two gunnery objectives, they were presented with 27 single moving targets engagements using the GPS and GAS. For the last two objectives, they were presented with 15 multiple (dual) stationary and moving target engagements using the GPS and GAS. Formal training on each objective took about 10 min to complete and ended when the last target presented was hit or disappeared from the display area. Recreational training on each objective took approximately 15 min to complete and ended when all 27 targets were destroyed or the gunner spent the 54 rounds of ammunition allocated for training the objective. In this training of novice gunners, the kill zone FMIP was set at 100% of the target box and the gunners were not required to hit a fixed percentage of targets before advancing to the next tank gunnery training objective. Training took place during a 1 day period and lasted about 2 hr per gunner.

In the third experiment, TOPGUN training consisted of three iterations of the nine tank gunnery training objectives (see Appendix A). These iterations were included to correspond with the three player experience levels (i.e., novice, qualified and

expert) on TOPGUN. Ideally, the standard of performance established for each objective should be 100% target hits. This would ensure that each gunner has acquired all the behaviors considered subordinate or prerequisite to subsequent, higher-order training objectives (e.g., can hit stationary targets before being required to hit moving targets). Since the soldiers were available only for a limited amount of time, imposing such a standard would have prevented some gunners from receiving the training needed to perform the more difficult target engagements. As a compromise solution, the gunners were required to destroy at least 70% of the targets presented before advancing to the next objective. Training took place over 4 consecutive days with the soldiers receiving about 9 hr of TOPGUN training. For the first three days, training was given in two 1 hr blocks each day with a 10 min break provided after the first hour. On the fourth day, training was given in three 1 hr blocks with a 10 min break provided after each hour.

Training and performance feedback provided by the research assistants to the gunners was minimal. The assistants helped the gunners use the device and corrected them when they were observed firing more than two rounds at a target or traversing the turret between engagements. Feedback on the accuracy of each round fired was provided to the gunners by the explosion graphic superimposed on the target by the TOPGUN system. The game data area directly below the WFOV in the device provided the gunners with the status of the training session (score, ammunition remaining, elapsed stage and game time, gun azimuth and elevation angles, range to target, and gun status).

Training Programs. Differences in the recreational and formal training programs produced some differences in the way targets were engaged by the gunners using the TOPGUN device. For both training groups, the engagements began when the target was handed-off to the gunner (i.e., the turret stopped slewing) and ended when the target was hit or disappeared from the viewing area.

In the formal training program, gunners were trained using a prescribed order of easy-to-difficult engagements. That is, they engaged single targets before multiple, stationary targets before moving, near targets before middle and distant, and flank targets before frontal and oblique. All targets were programed to appear within a 5 mil radius of the gunner's sight reticle. At that time, if the gunner was using the GPS or TIS, he placed the reticle on target, tracked the target if it was moving, lased (relased if necessary) to obtain the correct range, and fired. When using the GAS, the gunner laid the announced range line on the target. If the first round missed and time permitted, the gunner reengaged the target. To keep the number of rounds fired equal for gunners in the two training groups, they were told to fire only two rounds per engagement. Gunners were given approximately 16 s to complete a single engagement and about 28 s to complete a multiple engagement. Included in these times was a

5 s FMIP for the pseudo-loader to load the next round. After these fixed time periods, each target was programed to disappear from the gunner's field of view and another target to appear about 5 s later.

In the recreational training program, gunners engaged targets that were randomly generated by the TOPGUN computer. In this training program, any order of engagement difficulty was possible across trials (e.g., single or multiple; stationary or moving; flank, frontal, or oblique). Moreover, the targets could appear anywhere (range, azimuth) within the gunner's field of view. The procedures used by the gunners were the same as those described for the formal training program. However, there was no fixed time limit to complete a target engagement or begin the next engagement. That is, a engagement ended only when the target was hit. Subsequent engagements began based on the computer program and whether ammunition was still available.

Performance Measures

Four measures of accuracy and two measures of speed were selected for soldier tank gunnery performance evaluation. The four accuracy measures were: (a) percentage of hits, (b) percentage of targets hit, (c) percentage of first-round hits, and (d) rounds per target. The two speed measures were (a) hit rate and (b) fire rate. All six performance measures were based on main gun engagement hit-miss scores and elapsed times and are defined as follows:

Percentage of hits	= $\frac{\# \text{ targets hit}}{\# \text{ rounds fired}}$
Percentage of targets hit	= $\frac{\# \text{ targets hit}}{\# \text{ targets presented}}$
Percentage of first round hits	= $\frac{\# \text{ targets hit with first round}}{\# \text{ targets attempted}}$
Rounds per target	= $\frac{\# \text{ rounds fired}}{\# \text{ targets attempted}}$
Hit rate (per minute)	= $\frac{\# \text{ targets hit} \times 60}{\text{total exposure time for targets attempted}}$
Fire rate (per minute)	= $\frac{\# \text{ total rounds fired} \times 60}{\text{total exposure time for targets attempted}}$

Azimuth and elevation aiming errors and time to fire the first round at each target (opening time) measures were not selected due to problems in the TOPGUN computer analysis system.

Data Analyses

A three step procedure was used to analyze the data collected for each experiment. First, the pre- and posttest data were analyzed using a multivariate analysis of variance (MANOVA) to examine (a) if soldiers scores on the performance measures, on the whole, improved from pretest to posttest, and (b) if there were any group differences based on the difference scores from pretest to posttest. Second, a multivariate analysis of covariance (ANCOVA) was used to examine group differences on the posttest performance measures using the pretest measures as covariates. Appropriate univariate follow-ups and planned comparisons were analyzed when indicated by significant MANOVA results. For Experiment 3, these MANOVA procedures were repeated for I-COFT. Third, descriptive statistics were calculated for questionnaire data.

Results

Experiments 1 and 2

Description

In Experiments 1 and 2 combined, 23 soldiers waiting to attend the Cavalry Scout ANCOC at Fort Knox, KY and 24 officers waiting to attend AOB were randomly assigned to one of three groups; Formal (FORM), Recreational (REC), or No Training Group (NTG). The FORM group contained 16 soldiers, the REC group 15, and the NTG 16. Soldiers in the two training groups (REC, FORM) were pretested, trained on the device for 2 hr and posttested. Soldiers in the NTG were pre- and posttested. Since preliminary analyses showed that these two sets of subjects did not differ significantly on any of the performance measures, they were combined and analyzed together. The rationale for combining the subjects was to increase the sample size in the groups and thus statistical power.

The mean time in military service for the groups combined was 87.9 months for soldiers in the FORM group, 68.7 months for those in the REC group, and 73.8 months for those in the control (NTG) group. Collectively, the Cavalry Scout ANCOC soldiers held the military grade of Staff Sergeant and completed high school. The Pre-AOB officers held the military grade of second lieutenant and had completed college. Biographical data for the soldiers combined are summarized in Appendix M.

Training Effectiveness

TOPGUN Pre- and Posttest Group Analysis. Table 3 presents the means and standard deviations for Cavalry Scout and Pre-AOB soldiers' TOPGUN pre- and posttest performance measures. The mean performance of the groups is graphically illustrated in Figure 5.

Table 3

Means and Standard Deviations for Cavalry Scout ANCOG and Pre-AOB
TOPGUN Pre- and Posttest Performance Measures

<u>Dependent Measure</u>	<u>Test</u>	<u>Group</u>			
		<u>REC</u> <u>(n=15)</u>	<u>FORM</u> <u>(n=16)</u>	<u>NTG</u> <u>(n=16)</u>	<u>Total</u> <u>(N=47)</u>
Percentage of Hits	<u>Pretest</u>				
	M	.678	.635	.625	.645
	SD	.150	.159	.161	.155
	<u>Posttest</u>				
	M	.766	.770	.677	.740
Percentage of Targets Hit	SD	.102	.137	.125	.128
	<u>Pretest</u>				
	M	.828	.798	.777	.800
	SD	.147	.122	.135	.133
	<u>Posttest</u>				
Percentage of First Round Hits	M	.907	.905	.829	.880
	SD	.069	.082	.104	.093
	<u>Pretest</u>				
	M	.698	.651	.646	.664
	SD	.134	.174	.161	.156
Rounds Per Target	<u>Posttest</u>				
	M	.777	.800	.688	.754
	SD	.112	.125	.134	.131
	<u>Pretest</u>				
	M	1.281	1.380	1.348	1.337
Hit Rate (per minute)	SD	.113	.196	.197	.175
	<u>Posttest</u>				
	M	1.217	1.227	1.313	1.253
	SD	.100	.163	.165	.150
	<u>Pretest</u>				
Fire Rate (per minute)	M	6.006	5.515	5.389	5.629
	SD	1.631	1.584	1.487	1.556
	<u>Posttest</u>				
	M	6.750	7.102	5.787	6.542
	SD	1.248	1.789	1.481	1.598
Fire Rate (per minute)	<u>Pretest</u>				
	M	8.858	8.812	8.821	8.830
	SD	1.163	1.091	1.344	1.178
	<u>Posttest</u>				
	M	8.922	9.362	8.883	9.058
	SD	1.315	1.376	1.217	1.294

TOPGUN PERFORMANCE

CAVALRY SCOUT + PRE-AOB

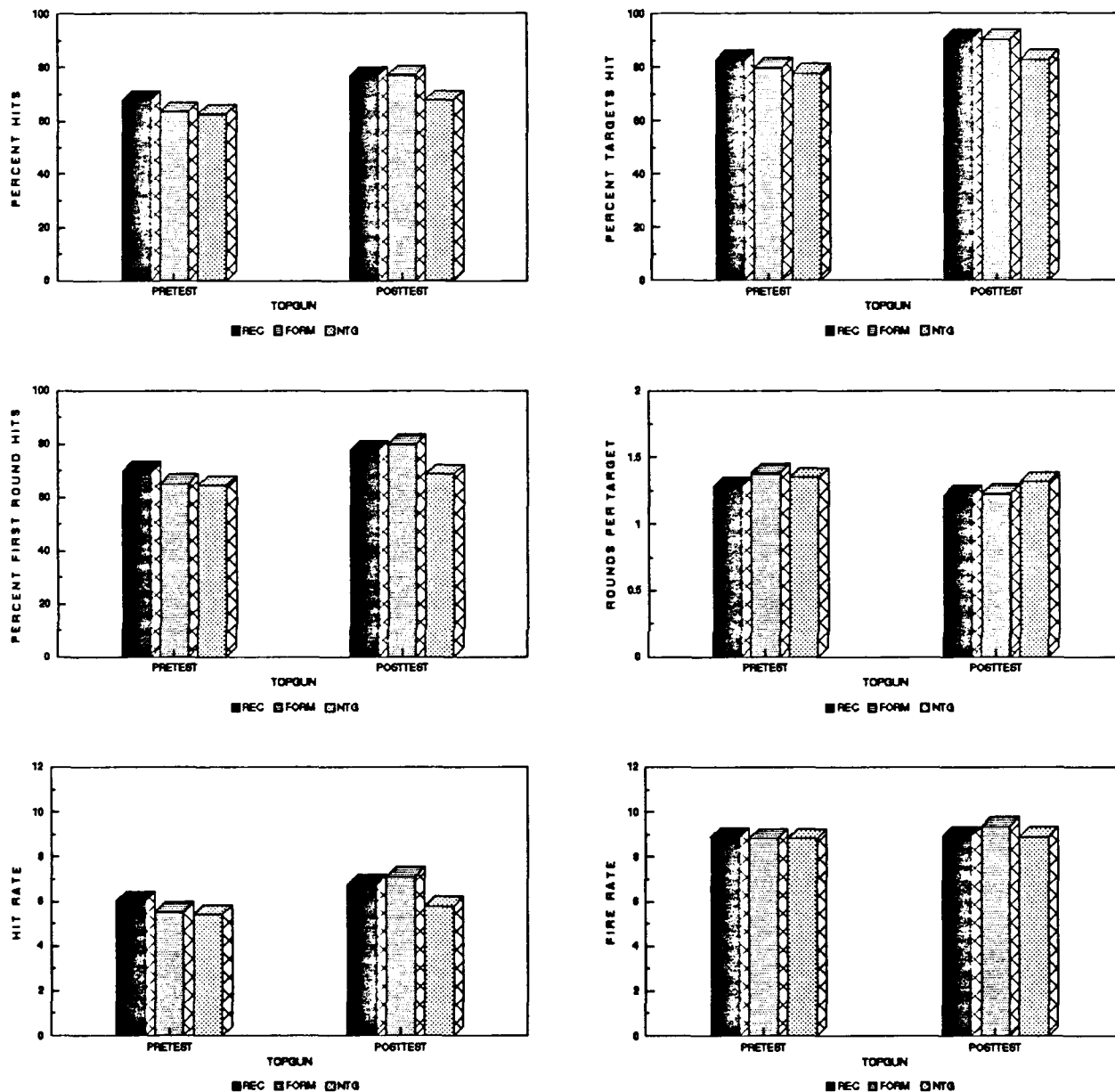


Figure 5. TOPGUN Performance of Soldiers in Experiments 1 and 2.

As the data suggest, the TOPGUN pretest and posttest is at an appropriate level of difficulty to allow variability in soldier performance. However, the data also suggest that ceiling effects are present for two of the six performance measures (Percentage of First Round Hits, Percentage of Targets Hit). Ceiling effects are undesirable because they restrict variance and, therefore, restrict the possible differences that could occur due to the training intervention. On closer examination of the data, it can be seen that the groups most affected by these measures are the two training groups (REC, FORM) on the posttest.

The correlation matrices for the TOPGUN pretest and posttest performance measures are presented in Appendix N, Table N-1. The measures are highly intercorrelated ($p < .01$) except for Fire Rate which did not correlate significantly with Percentage of First Round Hits, Rounds per Target, or Percentage of Hits on the pretest or posttest.

Table 4 presents the MANOVA results for the pretest-posttest main effect and Training Group by pretest-posttest interaction. The significant main effect (Wilk's lambda = .56, $p = .001$) shows there was significant improvement in the soldier's scores from TOPGUN pretest to posttest.

Table 4

TOPGUN Pre- and Posttest Repeated Measures MANOVA with Between Subject Training Effect.

Main Effect: Pretest-Posttest

<u>Test</u>	<u>Value</u>	<u>Approx F</u>	<u>Hyp df</u>	<u>Err df</u>	<u>p</u>
Pillais V	.43100	4.92360	6	39	.001
Hotellings	.75748	4.92360	6	39	.001
Wilk's Lambda	.56900	4.92360	6	39	.001
Roy's GCR	.43100				

Interaction: Training Group (REC, FORM, NTG) by Pretest-Posttest

<u>Test</u>	<u>Value</u>	<u>Approx F</u>	<u>Hyp df</u>	<u>Err df</u>	<u>p</u>
Pillais V	.32537	1.29527	12	80	.238
Hotellings	.43259	1.36986	12	76	.199
Wilk's Lambda	.68842	1.33408	12	78	.217
Roy's GCR	.27530				

As shown in Table 5, the follow-up univariate ANOVA for the pre- and posttest main effect were significant ($p < .001$) for all performance measures except Fire Rate, thus indicating a significant improvement from TOPGUN pretest to posttest on five of the six performance measures. However, the Training Group by

Pretest-Posttest interaction shown in Table 4 (Wilk's lambda = .68, $p = .217$) is not significant. That is, there were no significant differences in improvement on TOPGUN by Training Group based on the difference between TOPGUN pre- and posttest scores on the performance measures.

Table 5

Univariate ANOVA for TOPGUN Pre- and Posttest Main Effect.

<u>Measure</u>	<u>Hyp SS</u>	<u>Err SS</u>	<u>Hyp MS</u>	<u>Err MS</u>	<u>F</u>	<u>p</u>
% FRDHT	.18857	.33208	.18857	.00755	24.98536	.000*
% TGHIT	.14719	.24483	.14719	.00556	26.45317	.000*
RDS/TGT	.16387	.45783	.16387	.01041	15.74941	.000*
% HITS	.21290	.32121	.21290	.00730	29.16367	.000*
F-RATE	1.19026	22.09378	1.19026	.50213	2.37042	.131
H-RATE	19.42385	36.39734	19.42385	.82721	23.48110	.000*

Note: % FRDHT = Percentage of First Round Hits; % TGHIT = Percentage of Targets Hit; RDS/TGT = Rounds Per Target; % HITS = Percentage of Hits; F-RATE = Fire Rate; H-RATE = Hit Rate; * = $p < .001$

A multivariate ANCOVA was conducted on the TOPGUN posttest performance measures with the TOPGUN pretest performance measures as covariates (see Table 6). As shown, there was no significant main effect (Wilks's lambda = .60, $p = .125$). That is, soldiers did not perform significantly different on the TOPGUN posttest performance measures based on their group assignment.

Table 6

Multivariate ANCOVA for TOPGUN Posttest Performance Measures with Pretest Performance Measures as Covariates

Main Effect: Training Group (REC, FORM, NTG)

<u>Test</u>	<u>Value</u>	<u>Approx F</u>	<u>Hyp df</u>	<u>Err df</u>	<u>p</u>
Pillais V	.43511	1.57561	12	68	.120
Hotellings	.58088	1.54900	12	64	.130
Wilk's Lambda	.60634	1.56326	12	66	.125
Roy's GCR	.29422				

Soldiers' Attitudes

Questionnaire Analysis. The Soldier Opinion questionnaire contained two parts dealing with attitudes and experiences of soldiers in the use of the TOPGUN device. Because the soldiers were not experienced with the M1 tank, only the first part of the questionnaire was administered. Also, questionnaire Items 2 and 4 were considered not applicable (N/A). The questionnaire was completed by 15 Cavalry Scout ANCOC soldiers and 16 Pre-AOB officers in the two training groups after they spent 2 hr training on TOPGUN. A complete record of the questionnaire responses ratings is shown in Appendix N, Tables N-3.

The mean rating for the 14 items was 4.22. Generally, a 4.0 or higher average response on a five-point scale is indicative of strong positive feelings. Items with particularly positive ratings were:

<u>No.</u>	<u>Item Content</u>	<u>Rating 19D/AOB</u>
1.	I enjoyed training on the TOPGUN device.	4.75
7.	I had problems identifying the Most Dangerous Threat (reversed scored).	4.62
15.	I had trouble finding targets on TOPGUN (reversed scored).	4.59
6.	Most of the target engagements were too hard (reversed scored).	4.41
9.	TOPGUN helped me engage moving targets.	4.41
12.	TOPGUN training will make me a better gunner.	4.36

Summary

The results of Experiments 1 and 2 combined indicate significant improvement in gunnery performance from TOPGUN pretest to posttest. However, there was no significant difference in performance between the training groups and the control group. There was also no significant difference between the groups of soldiers who were trained using a recreational or formal training program. In retrospect, it appears that the effects of the pretest and hands-on training were sufficient to produce a training benefit. By examining the group means, it is evident that all three groups improved their performance scores from pretest to posttest. The experimental groups showed greater improvement, however, the improvement of the control group prompted by pretest practice effects made it more difficult to detect group differences. The overall attitudes of soldiers trained on TOPGUN were positive. They enjoyed training on the device and felt it would make them better gunners.

Experiment 3

Description

Thirty-six soldiers qualified as M1 Armor Crewmen (MOS 19K) were assigned to one of three groups (FORM, REC, NTG) based on a crude measure of gunnery performance derived from combined I-COFT and TOPGUN pretest scores. Soldiers were equally distributed to the three groups based on this data to ensure group equivalence with respect to gunner proficiency. Soldiers in the two training groups (REC, FORM) were pretested, given about 9 hr of training on TOPGUN over four consecutive days, and posttested. Soldiers in the control group (NTG) were only pre- and posttested. The experiment was conducted during a 12-week period with 12 soldiers participating every two weeks.

The mean time in military service was 65.67 months for soldiers in the FORM group, 64.67 months for soldiers in the REC group, and 69.00 months for soldiers in the NTG. Collectively, they held the military grade of Corporal to Staff Sergeant, completed high school, had a mean time of 17.14 months on the M1 tank with 6.5 months as a gunner, and spent an average of 90.64 hr on gunnery training devices. Biographical data for the soldiers are summarized in Appendix O.

Training Effectiveness

TOPGUN Pre- and Posttest Group Analysis. Table 7 presents the means and standard deviations by group for the TOPGUN pre- and posttest performance measures. The mean performance of the groups is graphically illustrated in Figure 6. Overall, there is less variability in the performance measures and the ceiling effects are more prevalent than those found in Experiments 1 and 2 combined.

The correlation matrices (Appendix P, Table P-1) suggest that the performance measures are highly intercorrelated ($p < .01$). The exception was Fire Rate which was not significantly correlated with Percentage of First Round Hits, Rounds Per Target, and Percentage of Hits on either the TOPGUN pretest or posttest.

Table 8 presents the MANOVA results for the TOPGUN pretest-posttest main effect and the Training Group by pretest-posttest interaction. As shown, a significant TOPGUN pretest-posttest main effect was found (Wilk's lambda = .31, $p < .001$). The follow-up univariate ANOVA (see Table 9) shows a significant effect ($p < .001$) for all six performance measures, thus indicating significant gunnery improvement from TOPGUN pretest to posttest for all groups combined.

As shown in Table 8, the Training Group by pretest-posttest interaction (Wilk's lambda = .54, $p = .098$) approaches statistical significance. Normally, a non-significant MANOVA finding suggests no further need for analyses. However, one of the main

Table 7

Means and Standard Deviations for M1 Armor Crewman (MOS 19K)
Soldiers' TOPGUN Pre- and Posttest Performance Measures

Dependent Measure	Test	Group			
		REC (n=12)	FORM (n=12)	NTG (n=12)	Total (N=36)
Percentage of Hits	<u>Pretest</u>				
	M	.753	.756	.764	.758
	SD	.092	.043	.100	.080
	<u>Posttest</u>				
	M	.865	.875	.792	.844
	SD	.053	.044	.069	.066
Percentage of Targets Hit	<u>Pretest</u>				
	M	.909	.912	.908	.910
	SD	.050	.028	.069	.051
	<u>Posttest</u>				
	M	.967	.977	.937	.960
	SD	.026	.023	.029	.031
Percentage of First Round Hits	<u>Pretest</u>				
	M	.757	.783	.774	.771
	SD	.100	.062	.084	.082
	<u>Posttest</u>				
	M	.856	.887	.802	.848
	SD	.056	.043	.100	.078
Rounds Per Target	<u>Pretest</u>				
	M	1.256	1.245	1.237	1.246
	SD	.108	.069	.104	.093
	<u>Posttest</u>				
	M	1.140	1.134	1.218	1.164
	SD	.057	.059	.088	.078
Hit Rate (per minute)	<u>Pretest</u>				
	M	7.429	7.259	7.540	7.409
	SD	1.528	.907	1.798	1.422
	<u>Posttest</u>				
	M	9.131	9.344	8.115	8.863
	SD	1.333	1.177	1.199	1.320
Fire Rate (per minute)	<u>Pretest</u>				
	M	10.524	10.163	10.250	10.312
	SD	1.218	1.039	1.147	1.115
	<u>Posttest</u>				
	M	11.005	10.917	10.672	10.865
	SD	1.093	1.498	.969	1.182

TOPGUN PERFORMANCE

M1 ARMOR CREWMEN

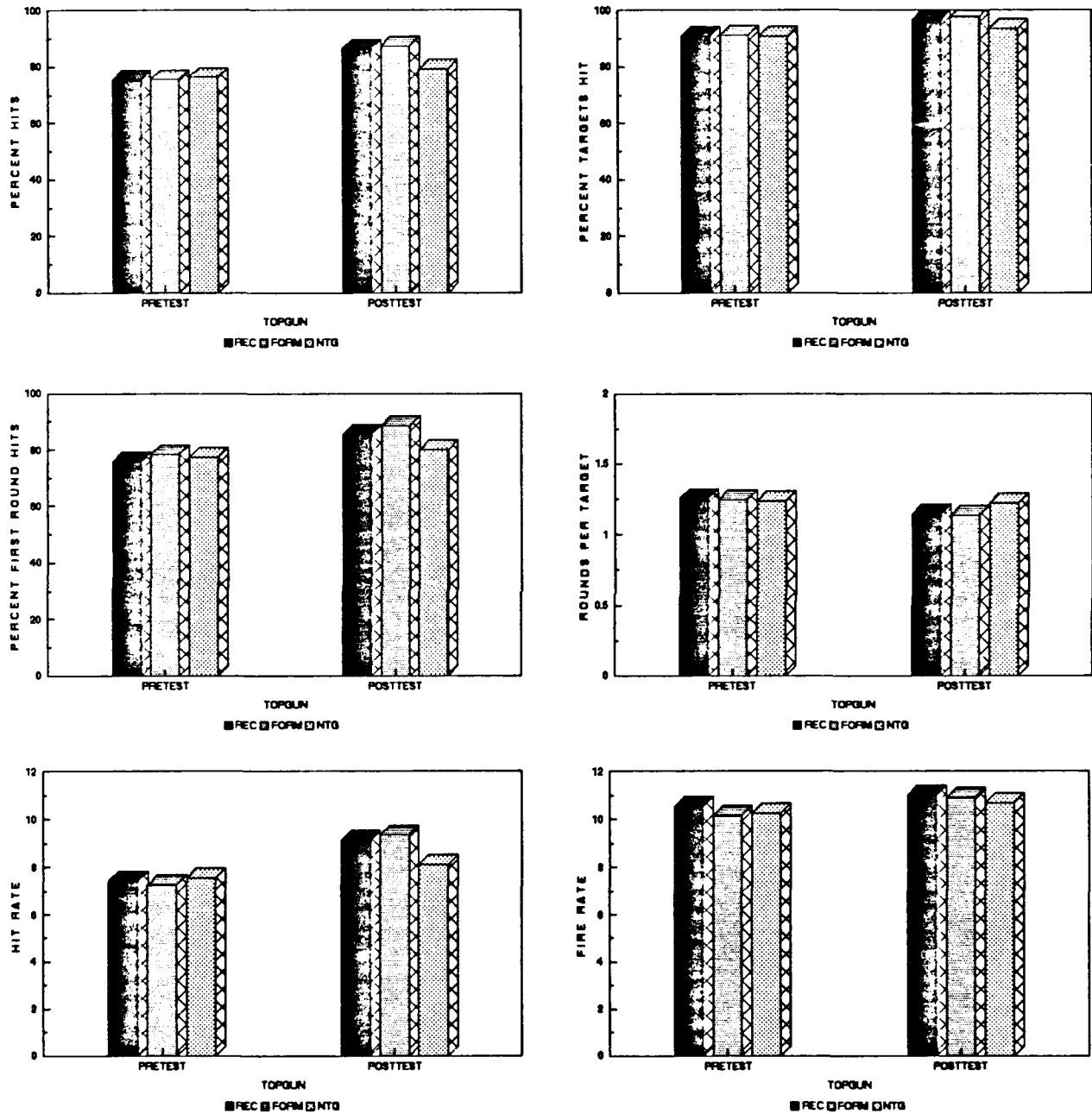


Figure 6. TOPGUN Performance of M1 Armor Crewmen.

Table 8

TOPGUN Pre- and Posttest Repeated Measures MANOVA with Between Subject Training Effect

Main Effect: Pretest-Posttest

<u>Test</u>	<u>Value</u>	<u>Approx F</u>	<u>Hyp df</u>	<u>Err df</u>	<u>p</u>
Pillais V	.68976	10.37552	6	28	.000
Hotellings	2.22333	10.37552	6	28	.000
Wilk's Lambda	.31024	10.37552	6	28	.000
Roy's GCR	.68976				

Interaction: Training Group (REC, FORM, NTG) by Pretest-Posttest

<u>Test</u>	<u>Value</u>	<u>Approx F</u>	<u>Hyp df</u>	<u>Err df</u>	<u>p</u>
Pillais V	.47439	1.50292	12	58	.150
Hotellings	.81495	1.83365	12	54	.066
Wilk's Lambda	.54197	1.67233	12	56	.098
Roy's GCR	.43696				

Table 9

Univariate ANOVA for TOPGUN Pre- and Posttest Main Effect.

<u>Measure</u>	<u>Hyp SS</u>	<u>Err SS</u>	<u>Hyp MS</u>	<u>Err MS</u>	<u>F</u>	<u>p</u>
% FRDHT	.10700	.10974	.10700	.00333	32.17554	.000*
% TGHIT	.04638	.02691	.04638	.00082	56.86553	.000*
RDS/TGT	.12053	.12476	.12053	.00378	31.87979	.000*
% HITS	.13425	.08326	.13425	.00252	53.20566	.000*
F-RATE	5.49314	21.44283	5.49314	.64978	8.45382	.006*
H-RATE	38.07055	28.58900	38.07055	.86633	43.94446	.000*

Note: % FRDHT = Percentage of First Round Hits; % TGHIT = Percentage of Targets Hit; RDS/TGT = Rounds Per Target; % HITS = Percentage of Hits; F-RATE = Fire Rate; H-RATE = Hit Rate; * = $p < .01$.

research questions was whether the training groups combined differed significantly from the Control (NTG) Group. Thus, with increased statistical power, the researchers chose to proceed with the follow-up univariate ANOVA and planned comparisons.

Table 10

Univariate ANOVA for Training Groups by TOPGUN Pretest-Posttest Interaction

<u>Measure</u>	<u>Hyp SS</u>	<u>Err SS</u>	<u>Hyp MS</u>	<u>Err MS</u>	<u>F</u>	<u>p</u>
% FRDHT	.02158	.10974	.01079	.00333	3.24540	.052
% TGHIT	.00420	.02691	.00210	.00082	2.57354	.091
RDS/TGT	.03522	.12476	.01761	.00378	4.65805	.017*
% HITS	.03119	.08326	.01560	.00252	6.18075	.005*
F-RATE	.37825	21.44283	.18912	.64978	.29106	.749
H-RATE	7.40038	28.58900	3.70019	.86633	4.27109	.022*

Note: % FRDHT = Percentage of First Round Hits; % TGHIT = Percentage of Targets Hit; RDS/TGT = Rounds Per Target; % HITS = Percentage of Hits; F-RATE = Fire Rate; H-RATE = Hit Rate; * = $p < .05$.

Table 11

Univariate ANOVA for Planned Comparisons of TOPGUN Training Groups Combined vs. Control Group

<u>Performance Measure</u>	<u>Value</u>	<u>Std Err</u>	<u>T-Value</u>	<u>df</u>	<u>p</u>
Percent 1st Rd Hits	-.10369810	.04078	-2.54308	33	.016*
Percent Targets Hit	-.04515932	.02019	-2.23633	33	.032*
Rounds Per Target	-.32567342	.04348	3.04908	33	.004**
Percent Hits	-.12460355	.03552	-3.50810	33	.001**
Fire Rate	-.27726428	.56999	-.48644	33	.630
Hit Rate	-1.8656391	.65815	-2.83465	33	.008**

Note: * = $p < .05$; ** = $p < .01$

As shown in Table 10, significant group differences ($p < .05$) were found on three of the six performance measures. However, as shown in Table 11, the added power achieved by combining the training groups led to significant group differences ($p < .05$) on five of the six performance measures for the planned comparisons.

Table 12 presents the multivariate ANCOVA conducted on the TOPGUN posttest measures with the TOPGUN pretest measures as covariates. As shown, the posttest main effect (Wilk's lambda = .44, $p = .070$) approaches significance. As discussed earlier, the researchers chose to proceed with the follow-up univariate ANOVA and planned comparisons of Training Groups combined versus the Control (NTG) Group.

Table 12

Multivariate ANCOVA for TOPGUN Posttest Performance Measures with Pretest Performance Measures as Covariates

Main Effect: Training Group (REC, FORM, NTG)

<u>Test</u>	<u>Value</u>	<u>Approx F</u>	<u>Hyp df</u>	<u>Err df</u>	<u>p</u>
Pillais V	.62956	1.76096	12	46	.084
Hotellings	1.09654	1.91894	12	42	.060
Wilk's Lambda	.44257	1.84495	12	44	.070
Roy's GCR	.43696				

Table 13 shows the follow-up ANOVA for the TOPGUN posttest main effect. As shown, significant group differences ($p < .01$) were found on four of the measures. As shown in Table 14, however, the additional statistical power achieved by combining the training groups led to significant group differences ($p < .05$) on five of the six performance measures. Also, four of those five performance measures were significant at the $p < .01$ level.

Training Transfer

I-COFT Pre- and Posttest Group Analysis. Table 15 presents the means and standard deviations by group for the I-COFT pre- and posttest performance measures. The mean performance of the groups is graphically illustrated in Figure 7. As the data suggest, the tests appear to be at an appropriate level of difficulty to allow variability in the performance measures. There is some evidence of ceiling effects but it is not as prevalent as that found with TOPGUN. Again, the modest variability in performance measures produced by the ceiling effects may hinder the finding of significant group differences.

Table 13

Univariate ANOVA for Posttest Main Effect with Pretest Performance Measures as Covariates

<u>Measure</u>	<u>Hyp SS</u>	<u>Err SS</u>	<u>Hyp MS</u>	<u>Err MS</u>	<u>F</u>	<u>p</u>
% FRDHT	.04283	.09983	.02142	.00370	5.79221	.008**
% TGHIT	.00748	.01126	.00374	.00042	8.96122	.001**
RDS/TGT	.04839	.10633	.02420	.00394	6.14440	.006**
% HITS	.04347	.06727	.02173	.00249	8.72337	.001**
F-RATE	.03692	29.11057	.01846	1.07817	.01712	.983
H-RATE	6.75228	27.86365	3.37644	1.03199	3.27178	.053

Note: % FRDHT = Percentage of First Round Hits; % TGHIT = Percentage of Targets Hit; RDS/TGT = Rounds Per Target; % HITS = Percentage of Hits; F-RATE = Fire Rate; H-RATE = Hit Rate; ** = $p < .01$.

Table 14

Univariate ANOVA for Planned Comparisons of TOPGUN Training Groups Combined vs. Control Group with TOPGUN Pretest Performance Measures as Covariates

<u>Performance Measure</u>	<u>Value</u>	<u>Std Err</u>	<u>T-Value</u>	<u>df</u>	<u>p</u>
Percent 1st Rd Hits	-.142753588	.04631	3.08234	33	.005**
Percent Targets Hit	-.062261935	.01556	4.00255	33	.000**
Rounds Per Target	-.16699373	.04780	-3.49386	33	.002**
Percent Hits	-.15655176	.03802	4.11813	33	.000**
Fire Rate	-.126462783	.79085	.15991	33	.874
Hit Rate	1.88567481	.77373	2.437135	33	.022*

Note: * = $p < .05$; ** = $p < .01$.

Table 15

Means and Standard Deviations for M1 Armor Crewman (MOS 19K)
Soldiers' I-COFT Pre- and Posttest Performance Measures

<u>Dependent Measure</u>	<u>Test</u>	<u>Group</u>			
		<u>REC</u> <u>(n=12)</u>	<u>FORM</u> <u>(n=12)</u>	<u>NTG</u> <u>(n=12)</u>	<u>Total</u> <u>(N=36)</u>
Percentage of Hits	<u>Pretest</u>				
	M	.696	.708	.744	.716
	SD	.149	.146	.139	.142
	<u>Posttest</u>				
	M	.824	.800	.812	.812
	SD	.092	.075	.097	.086
Percentage of Targets Hit	<u>Pretest</u>				
	M	.629	.646	.647	.641
	SD	.199	.181	.209	.191
	<u>Posttest</u>				
	M	.788	.763	.807	.786
	SD	.156	.125	.114	.131
Percentage of First Round Hits	<u>Pretest</u>				
	M	.735	.735	.749	.740
	SD	.133	.133	.146	.134
	<u>Posttest</u>				
	M	.837	.815	.819	.824
	SD	.126	.084	.095	.101
Rounds Per Target	<u>Pretest</u>				
	M	1.146	1.188	1.127	1.154
	SD	.072	.098	.055	.079
	<u>Posttest</u>				
	M	1.085	1.142	1.095	1.107
	SD	.096	.081	.056	.081
Hit Rate (per minute)	<u>Pretest</u>				
	M	2.825	2.968	2.884	2.892
	SD	.817	1.110	.726	.875
	<u>Posttest</u>				
	M	3.381	3.159	3.324	3.288
	SD	.489	.472	.528	.492
Fire Rate (per minute)	<u>Pretest</u>				
	M	4.375	4.373	4.264	4.337
	SD	.492	1.173	.468	.762
	<u>Posttest</u>				
	M	4.308	4.203	4.275	4.262
	SD	.330	.409	.344	.355

I-COFT PERFORMANCE

M1 ARMOR CREWMEN

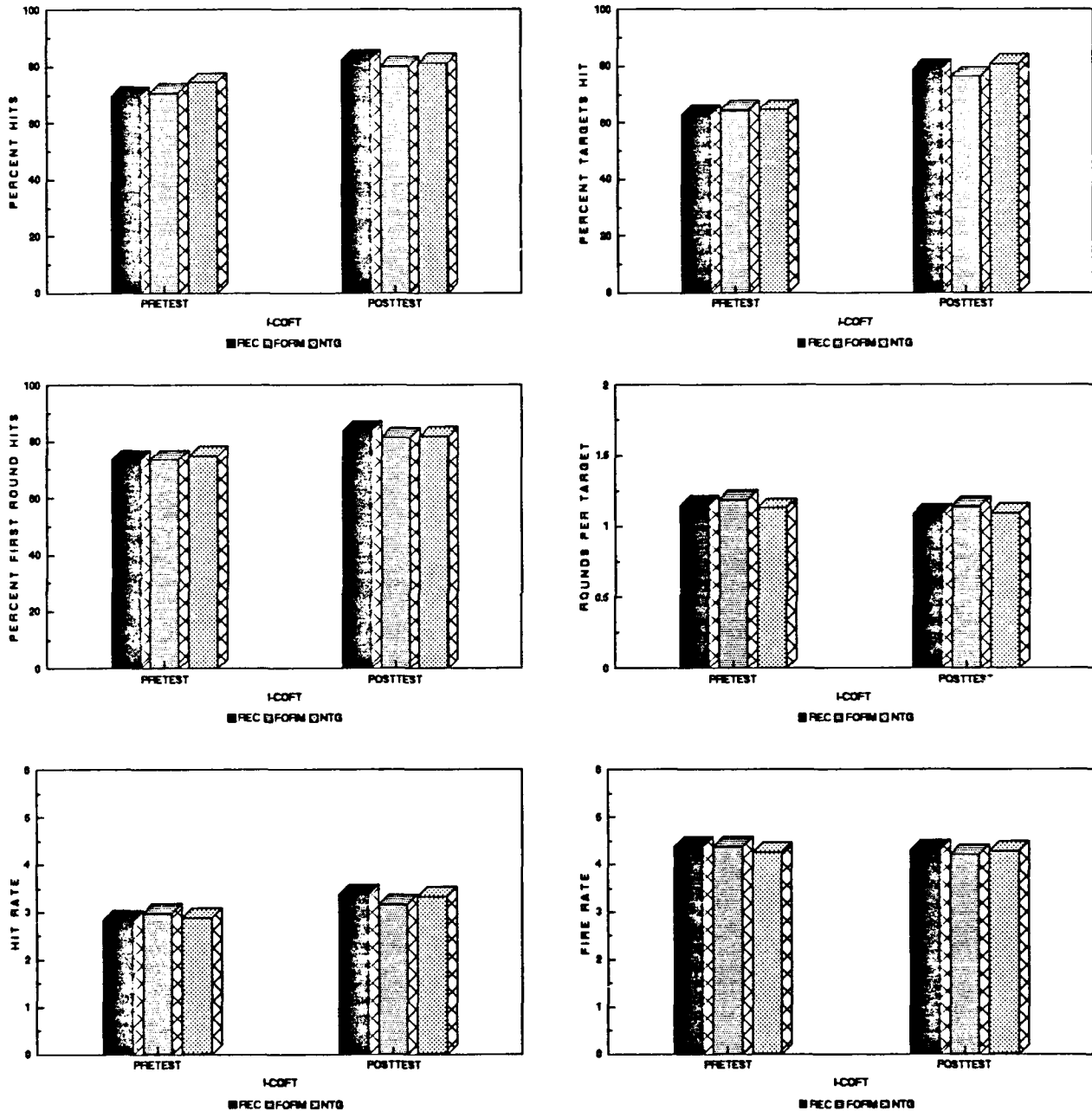


Figure 7. I-COFT Performance of M1 Armor Crewmen.

On the I-COFT pretest, significant intercorrelations ($p < .01$) were found among all six performance measures except for Fire Rate with Percentage of First Round Hits, Percentage of Targets Hit, Rounds Per Target, and Percentage of Hits. On the I-COFT posttest, all correlations were significant ($p < .01$) except (a) Firing Rate with Percentage of First Round Hits, Percentage of Targets Hit, Rounds Per Target, and Percentage of Hits and (b) Rounds Per Target with all six performance measures. The correlation matrices are presented in Appendix P, Table P-2.

Table 16 presents the MANOVA results for the I-COFT Training Group by pretest-posttest interaction and the pretest-posttest main effect. As shown, a significant I-COFT pretest-posttest main effect was found (Wilk's lambda = .45, $p = .001$).

Table 16

I-COFT Pre- and Posttest Repeated Measures MANOVA with Between Subject Training Effect.

Main Effect: Pretest-Posttest

<u>Test</u>	<u>Value</u>	<u>Approx F</u>	<u>Hyp df</u>	<u>Err df</u>	<u>p</u>
Pillais V	.54678	5.63007	6	28	.001
Hotellings	1.20644	5.63007	6	28	.001
Wilk's Lambda	.45322	5.63007	6	28	.001
Roy's GCR	.54678				

Interaction: Training Group (REC, FORM, NTG) by Pretest-Posttest

<u>Test</u>	<u>Value</u>	<u>Approx F</u>	<u>Hyp df</u>	<u>Err df</u>	<u>p</u>
Pillais V	.29282	.82901	12	58	.621
Hotellings	.35950	.80887	12	54	.640
Wilk's Lambda	.72354	.81959	12	56	.630
Roy's GCR	.21770				

As shown in Table 17, the follow-up univariate ANOVA were significant for all performance measures ($p < .01$) except Fire Rate, thus suggesting significant improvement in performance by the soldiers from I-COFT pretest to posttest for these measures. However, as shown in Table 16, the Training Group by I-COFT pretest-posttest interaction (Wilk's lambda = .72, $p = .630$) is not significant. That is, group differences based on TOPGUN training were not significant to suggest I-COFT training transfer.

Although overall performance improved from the I-COFT pretest to posttest, the lack of significant group differences does not suggest that improvement in performance is attributable to TOPGUN training. It is possible that group differences could have been detected with a larger sample size and more difficult

Table 17

Univariate ANOVA for I-COFT Pre- and Posttest Main Effect.

<u>Measure</u>	<u>Hyp SS</u>	<u>Err SS</u>	<u>Hyp MS</u>	<u>Err MS</u>	<u>F</u>	<u>p</u>
% FRDHT	.12752	.24999	.12752	.00758	16.83361	.000**
% TGHIT	.37797	.33693	.37797	.01021	37.01896	.000**
RDS/TGT	.03956	.24413	.03956	.00740	5.34721	.027
% HITS	.16725	.25854	.16725	.00783	21.34780	.000**
F-RATE	.10157	9.18295	.10157	.27827	.36501	.550
H-RATE	2.81488	8.09431	2.81488	.24528	11.47607	.002**

Note: % FRDHT = Percentage of First Round Hits; % TGHIT = Percentage of Targets Hit; RDS/TGT = Rounds Per Target; % HITS = Percentage of Hits; F-RATE = Fire Rate; H-RATE = Hit Rate; ** = $p < .01$.

test engagements to eliminate ceiling effects and the resulting reduction in score variance. Again, it appears that the I-COFT and TOPGUN pretests provided some training benefit. The means show that control group performance improved on both device posttests. This makes the detection of group differences based on change scores from pretest to posttest more difficult.

A multivariate analyses of covariance was conducted on the I-COFT posttest measures with the I-COFT pretest performance measures as covariates. As shown in Table 18, the Training Group main effect (Wilk's lambda = .56, $p = .303$) is not significant.

Table 18

Multivariate ANCOVA for I-COFT Posttest Performance Measures with Pretest Performance Measures as Covariates

Main Effect: Training Group (FORM, REC, NTG)					
<u>Test</u>	<u>Value</u>	<u>Approx F</u>	<u>Hyp df</u>	<u>Err df</u>	<u>p</u>
Pillais	.48325	1.22135	12	46	.298
Hotellings	.68869	1.20521	12	42	.311
Wilk's Lambda	.56412	1.21520	12	44	.303
Roy's GCR	.34655				

Soldiers' Attitudes and Experiences

Questionnaire Analysis. The Soldier Opinion Questionnaire contained two parts dealing with attitudes and experiences of soldiers in the use of TOPGUN. The questionnaire was completed by 12 soldiers in each of the two training groups (REC, FORM) after 9 hr of TOPGUN training. The complete ratings of the two groups is presented in Appendix Q, Table Q-3.

Part One. For the Recreational (REC) training group the mean rating for the 16 items was 4.26. For the Formal (FORM) training group it was 4.00. Generally, a 4.0 or higher average response on a five-point scale is indicative of strong positive feelings. No statistical difference was found between the average mean ratings of the two groups. However, significant differences ($p < .05$) were found between the mean ratings for the two groups on four of the 16 items. These items along with their ratings for the two groups are shown below.

<u>No.</u>	<u>Item Content</u>	<u>Rating</u>	
		<u>REC</u>	<u>FORM</u>
3.	TOPGUN helped me improve my tank gunnery skills.	4.70	3.75
6.	Most of the target engagements were too hard (reversed scored).	4.10	4.75
8.	I would use TOPGUN to sustain my gunnery skills.	4.70	3.67
10.	I liked the voice commands for target engagements.	4.40	3.25

As shown, there is an obvious preference of soldiers in the REC group for using TOPGUN to improve (Item 3) and sustain (Item 8) their tank gunnery skills. FORM group soldiers held the same attitude, but to a lesser extent. Also, soldiers in the REC group considered the difficulty of the engagements (Item 6) to be opposite of those in the FORM group. These differences are consistent with the differences between the two training methods employed when using the device. Soldiers in the REC group were presented with multiple target arrays throughout most of their training, with at least two and sometimes as many as four targets appearing in the target display area at any one time. In many engagements, targets traveled as fast as 40 mph and appeared at ranges of up to 4000 m. Soldiers in the FORM group on the other hand were required to engage single stationary and moving targets before attempting multiple target engagements. The maximum range to target was set at 2400 m and speed of the target was limited to 10-12 mph. In addition, multiple target engagements consisted of no more than two targets presented at a time.

To determine the overall opinions of the 24 soldiers who trained on TOPGUN, the mean ratings of the two training groups on the 16 items were combined and averaged. The (average mean) rating for the two groups was 4.12. No strong negative ratings were indicated. The items that were found with particularly positive ratings were:

<u>No.</u>	<u>Item Content</u>	<u>Rating</u>
15.	I had trouble finding the targets on TOPGUN (reversed scored).	4.64
1.	I enjoyed training on the TOPGUN device.	4.59
6.	Most of the target engagements were too hard (reversed scored).	4.45
11.	I could use TOPGUN without any instructor assistance.	4.36
9.	TOPGUN helped me to engage moving targets.	4.27
16.	I liked the "unity window" for locating targets.	4.27
3.	TOPGUN helped me improve my tank gunnery skills.	4.18
8.	I would use TOPGUN to sustain my gunnery skills.	4.14
12.	TOPGUN training will make me a better gunner.	4.14

Part Two. For the REC group the mean rating of the realism of the TOPGUN device for all 14 items was 4.24; for the FORM group it was 3.56. Thus, soldiers in the REC group tended to view the device midway between "very realistic" and "extremely realistic" while those in the FORM group rated the device midway between "moderately realistic" and "very realistic".

There was no statistical difference between the average mean ratings of the two training groups on all items combined. However, differences between the groups' mean ratings on three of the 14 items were significant ($p < .05$). These items with their mean ratings are as shown:

<u>No.</u>	<u>Item Content</u>	<u>Rating</u>	
		<u>REC</u>	<u>FORM</u>
27.	Fire commands.	4.70	3.91
21.	TIS reticle.	4.50	3.53
19.	Laser rangefinder.	4.30	3.09

To determine the overall opinion of the 24 soldiers who trained on TOPGUN, the mean ratings of the two training groups on the 14 items were combined. The (average mean) rating for the two groups combined was 3.89. The equipment and functions that were rated "very realistic" or higher were:

<u>No.</u>	<u>Item Content</u>	<u>Rating</u>
26.	TC override.	4.38
29.	Fire commands.	4.29
25.	Visual scenes (targets, background, trees, etc.).	4.24
24.	System status information (Ready-to-fire & "F").	4.19
23.	Range data display in sight.	4.10
20.	GPS reticle.	4.00
21.	TIS reticle.	4.00

Except for Item 28 (sight obscuration after firing), the remaining equipment and functions were viewed as "moderately realistic".

Summary

The results clearly indicate a significant improvement in soldier tank gunnery proficiency from TOPGUN and I-COFT pretest to posttest on the six performance measures of firing accuracy and speed. Although the overall MANOVA for TOPGUN Training Group by pretest-posttest interaction only approached significance, the additional power gained by combining the Training groups and comparing those soldiers with the Control group led to significant findings for five of the performance measures with the Training groups improving more from pretest to posttest compared to the Control group. Similar results were found with the multivariate ANCOVA indicating significantly better performance by the Training Groups combined on four of the posttest measures using the pretest measures as covariates.

In terms of training transfer, although performance for the soldiers improved from pretest to posttest, soldiers who were trained on TOPGUN did not perform significantly different from those in the control group on I-COFT on any of the performance measures. That is, soldiers who received 9 hr of recreational or formal training on TOPGUN did not perform significantly better on the six performance measures from I-COFT pretest to posttest than those who did not receive training. There were no significant differences in I-COFT performance between the two training groups. Soldiers who were trained on TOPGUN using the

recreational approach did not perform significantly different than those trained following a formal approach on the six performance measures.

In terms of soldiers' attitudes and experiences regarding TOPGUN, the responses were highly positive. Soldiers who were trained using a recreational or free-play approach felt they could use TOPGUN to improve and sustain their tank gunnery skills. Soldiers who were trained using a formal or structured approach felt the same way, but to a lesser extent. The average mean rating for the two groups was very positive with no strong negative ratings indicated. Except for "sight obscuration after firing," TOPGUN equipment and functions were viewed "moderately realistic" with half of the items rated "very realistic" or higher.

General Discussion and Conclusions

Training Effectiveness

The analysis of the TOPGUN pre- and posttest data clearly support the conclusion that basic tank gunnery skills were learned on the device. In the first two experiments, neither the Cavalry Scout ANCOC soldiers nor the Pre-AOB officers who served as research participants had previous tank gunnery experiences. Nevertheless, with minimal device familiarization and hands-on practice, their performance significantly improved from pretest to posttest on all six performance measures. In the third experiment, significant improvements in gunnery performance from pretest to posttest were found for soldiers who were already qualified as armor tank crewmen and possessed tank gunnery experience. Also, soldiers in the two training groups combined (REC, FORM) demonstrated greater improvement compared to those in the control group (NTG).

In the first two experiments combined, the performance means indicate that the two training groups improved more from pretest to posttest as compared to the control group. This difference between the groups, however, was not significant. There were also no significant group differences found between soldiers who were trained on the device using a recreational approach and those who followed a formal training strategy.

By combining and analyzing the data from Experiments 1 and 2, sample size should have been adequate to detect differences between groups. Since it was not, there are other plausible reasons for not finding significant differences. For example, reduced score variance was present in some of the performance measures produced by ceiling effects found with some of the TOPGUN exercises. Also, the practice effects of the TOPGUN pretest and hands-on training led to an increase in performance for control group soldiers from pretest to posttest. Experiment 3 also was affected by these problems and a reduced sample size.

One possible explanation for the ceiling effects is that the difficulty level of the target engagement for testing gunnery performance was too low. In the first two experiments, the kill zone parameter for getting a target hit was set at 100% of the target box. This seemed reasonable at the time because the soldiers who were participating in the research had no gunnery experience. As the pretest data suggest, however, nearly 80% of the targets attempted were hit. In fact, for the nine single stationary target engagements included in the 30-item test, many of the soldiers were able to obtain a perfect score. A more likely explanation is that learning occurred during both the TOPGUN familiarization training and the pretest, and that this learning elevated already high ceiling effects. Support for this explanation is provided in research conducted by Hart, Hagman and Bowne (1989). They found the mean accuracy scores of soldiers after just ten stationary target trials to be over 90%. In retrospect, it would have been best to reduce such learning effects by ensuring group equivalence before training on the basis of biographical data and administering only a posttest.

In the third experiment, there were significant differences found in the gunnery performance of soldiers who were trained for 9 hr and those who did not receive the additional training (i.e., the performance of the two training groups improved more than the control group). There was, however, no significant difference between soldiers who were trained using a recreational approach and those who followed a formal training strategy. One possible explanation for not finding a significant difference between groups is that gunners were required to hit at least 70% of the targets before advancing to the next gunnery objective. Although there were no gunners who failed to meet the performance standard, this requirement could have reduced any differences that might have occurred between the two training groups. It also may have contributed to the high ceiling effects.

A larger sample size in the third experiment would have likely increased the probability of finding differences between the training approaches if, in fact they existed. However, the real reason for not finding group differences was due to the performance ceiling effects. The effects of learning that occurred during the TOPGUN familiarization training and pretest were a major contributing factor, as was the established level of target engagement difficulty. This latter factor was thought to have been controlled by setting the kill zone parameter to 50% of the target box in order for the gunner to obtain a hit. The results indicate, however, that the experience level of the gunners negated the increased difficulty of the engagements. As the data show, the experienced gunners were still able to hit nearly 90% of the targets on the TOPGUN pretest.

Training Transfer

To assess training transfer of TOPGUN acquired skills to I-COFT, an I-COFT pretest and posttest were administered to all

soldiers. Six performance measures (four accuracy measures and two speed measures) were examined for group differences. The results of the analyses found significant gunnery performance improvements from I-COFT pretest to posttest for all soldiers. However, no significant differences were found between the Training Groups and the Control Group on the performance measures suggesting that training on TOPGUN transferred or led to improved performance on I-COFT. As such, there were no significant differences found between the two training groups.

A major factor which may have hindered transfer effects involves basic differences between the performance requirements for the two devices. That is, soldiers trained on TOPGUN were not required to move from a hull-down position to engage stationary targets. As such, they did not have to tell the driver to move out, locate the target in the GAS, direct the driver to stop, relocate the target using the GPS or TTS, or switch from 3x to 10x magnification before lasing and firing. In TOPGUN, the GPS and TTS reticle does not shift after lasing to a target. Thus, it is much easier during both stationary and moving engagements for the gunner to keep the reticle precisely on the target center of mass before firing. Moreover, the gunner can sit back and look at the reticle and target projected on the screen as opposed to looking through the monocular eyepiece of the primary or secondary sights. Given these unique differences in the skill requirements for the two devices, the effects of skills learned during I-COFT pretesting may have completely masked any general skills training transfer from TOPGUN.

As discussed previously, the possibility of finding significant group differences was hampered by the small number of soldiers used in the comparison and the prevalent ceiling effects created by (a) the learning that occurred during TOPGUN familiarization training and TOPGUN and I-COFT pretesting and (b) the low level of target engagement difficulty on the TOPGUN and I-COFT tests. The questions of whether TOPGUN training would transfer or lead to improved I-COFT performance and whether a difference exists between free-play or structured training approaches that would make one approach more conducive to training transfer remain unanswered by the present research. In future TOPGUN research, power tests should be performed to estimate the required sample size. Decisions about probability levels and numbers of subjects can then be made considering practicality, costs and other such considerations. Moreover, to negate possible ceiling effects, group equivalency should be based on biographical data rather than pretesting. Also, the kill zone for obtaining a target hit should be set to a much more difficult level (e.g. 25%). This is especially critical if the research participants are experienced, qualified tank gunners.

Soldiers' Attitudes and Experiences

Soldiers attitudes and experiences using the TOPGUN part-task gunnery training device were extremely favorable. The device is viewed as realistic and challenging for soldiers even

though it only simulated some of the high fidelity features associated with the I-COFT. Even soldiers who trained on the device for nearly 9 hr over four consecutive days did not appear "burned out." They monitored their scores during training and were motivated to improve their performance across training sessions. Nearly everyone trained on TOPGUN indicated they would use the device in their spare time if one was available in their barracks or dayroom.

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APPENDIX A

**Target Engagement Formats for
Training Novice Gunners
on TOPGUN**

TRAINING OBJECTIVE I
ENGAGE STATIONARY TARGETS WITH MAIN GUN USING GPS

NOVICE GUNNER

TRIAL	NUMBER & TARGET	TARGET RANGE	TARGET SPEED	TARGET MOVEMENT	KILL ZONE	FIRE COMMAND	AMMO	TIME
STAGE I								
1	1 TANK	12-1300	STA	FLANK	100%	G-S-T	APDS	16
2		13-1400						
3		14-1500						
4	1 TANK	12-1300	STA	FRONTAL	100%	G-S-T	APDS	16
5		13-1400						
6		14-1500						
7	1 TANK	12-1300	STA	OBLIQUE	100%	G-S-T	APDS	16
8		13-1400						
9		14-1500						
STAGE II								
10	1 TANK	15-1600	STA	FLANK	100%	G-S-T	APDS	16
11		16-1700						
12		17-1800						
13	1 TANK	15-1600	STA	FRONTAL	100%	G-S-T	APDS	16
14		16-1700						
15		17-1800						
16	1 TANK	15-1600	STA	OBLIQUE	100%	G-S-T	APDS	16
17		16-1700						
18		17-1800						
STAGE III								
19*	1 TANK	18-2000	STA	FLANK	100%	G-S-T	APDS	16
20		20-2200						
21		22-2400						
22	1 TANK	18-2000	STA	FRONTAL	100%	G-S-T	APDS	16
23*		20-2200						
24		22-2400						
25	1 TANK	18-2000	STA	OBLIQUE	100%	G-S-T	APDS	16
26		20-2200						
27*		22-2400						

Note: Asterisk (*) indicates target engagements selected for TOPGUN pre- and posttest for Experiment 1 and 2.

TRAINING OBJECTIVE II
ENGAGE STATIONARY TARGETS WITH MAIN GUN USING TTS

NOVICE GUNNER

TRIAL	NUMBER & TARGET	TARGET RANGE	TARGET SPEED	TARGET MOVEMENT	KILL ZONE	FIRE COMMAND	AMMO	TIME
<u>STAGE I</u>								
1	1 TANK	12-1300	STA	FLANK	100%	G-S-T	APDS	16
2		13-1400						
3		14-1500						
4	1 TANK	12-1300	STA	FRONTAL	100%	G-S-T	APDS	16
5		13-1400						
6		14-1500						
7	1 TANK	12-1300	STA	OBLIQUE	100%	G-S-T	APDS	16
8		13-1400						
9		14-1500						
<u>STAGE II</u>								
10	1 TANK	15-1600	STA	FLANK	100%	G-S-T	APDS	16
11		16-1700						
12		17-1800						
13	1 TANK	15-1600	STA	FRONTAL	100%	G-S-T	APDS	16
14		16-1700						
15		17-1800						
16	1 TANK	15-1600	STA	OBLIQUE	100%	G-S-T	APDS	16
17		16-1700						
18		17-1800						
<u>STAGE III</u>								
19	1 TANK	18-2000	STA	FLANK	100%	G-S-T	APDS	16
20		20-2200						
21*		22-2400						
22*	1 TANK	18-2000	STA	FRONTAL	100%	G-S-T	APDS	16
23		20-2200						
24		22-2400						
25	1 TANK	18-2000	STA	OBLIQUE	100%	G-S-T	APDS	16
26*		20-2200						
27		22-2400						

Note: Asterisk (*) indicates target engagements selected for M1 TOPGUN pre- and posttest for Experiment 1 and 2.

TRAINING OBJECTIVE III
ENGAGE STATIONARY TARGETS WITH MAIN GUN USING GAS

NOVICE GUNNER

TRIAL	NUMBER & TARGET	TARGET RANGE	TARGET SPEED	TARGET MOVEMENT	KILL ZONE	FIRE COMMAND	AMMO	TIME
<u>STAGE I</u>								
1	1 TANK	12-1300	STA	FLANK	100%	G-S-T-R	APDS	16
2		13-1400						
3		14-1500						
4	1 TANK	12-1300	STA	FRONTAL	100%	G-S-T-R	APDS	16
5		13-1400						
6		14-1500						
7	1 TANK	12-1300	STA	OBLIQUE	100%	G-S-T-R	APDS	16
8		13-1400						
9		14-1500						
<u>STAGE II</u>								
10	1 TANK	15-1600	STA	FLANK	100%	G-S-T-R	APDS	16
11		16-1700						
12		17-1800						
13	1 TANK	15-1600	STA	FRONTAL	100%	G-S-T-R	APDS	16
14		16-1700						
15		17-1800						
16	1 TANK	15-1600	STA	OBLIQUE	100%	G-S-T-R	APDS	16
17		16-1700						
18		17-1800						
<u>STAGE III</u>								
19	1 TANK	18-2000	STA	FLANK	100%	G-S-T-R	APDS	16
20*		20-2200						
21		22-2400						
22	1 TANK	18-2000	STA	FRONTAL	100%	G-S-T-R	APDS	16
23		20-2200						
24*		22-2400						
25*	1 TANK	18-2000	STA	OBLIQUE	100%	G-S-T-R	APDS	16
26		20-2200						
27		22-2400						

Note: Asterisk (*) indicates target engagements selected for M1 TOPGUN pre- and posttest for Experiment 1 and 2.

TRAINING OBJECTIVE IV
ENGAGE MOVING TARGETS WITH MAIN GUN USING GPS

NOVICE GUNNER

TRIAL	NUMBER & TARGET	TARGET RANGE	TARGET SPEED	TARGET MOVEMENT	KILL ZONE	FIRE COMMAND	AMMO	TIME
STAGE I								
1	1 TANK	12-1300	MOV	FLANK	100%	G-S-MT	APDS	16
2		13-1400						
3		14-1500						
4	1 TANK	12-1300	MOV	FRONTAL	100%	G-S-MT	APDS	16
5		13-1400						
6		14-1500						
7	1 TANK	12-1300	MOV	OBLIQUE	100%	G-S-MT	APDS	16
8		13-1400						
9		14-1500						
STAGE II								
10	1 TANK	15-1600	MOV	FLANK	100%	G-S-MT	APDS	16
11		16-1700						
12		17-1800						
13	1 TANK	15-1600	MOV	FRONTAL	100%	G-S-MT	APDS	16
14		16-1700						
15		17-1800						
16	1 TANK	15-1600	MOV	OBLIQUE	100%	G-S-MT	APDS	16
17		16-1700						
18		17-1800						
STAGE III								
19	1 TANK	18-2000	MOV	FLANK	100%	G-S-MT	APDS	16
20		20-2200						
21*		22-2400						
22	1 TANK	18-2000	MOV	FRONTAL	100%	G-S-MT	APDS	16
23*		20-2200						
24		22-2400						
25*	1 TANK	18-2000	MOV	OBLIQUE	100%	G-S-MT	APDS	16
26		20-2200						
27		22-2400						

Note: Asterisk (*) indicates target engagements selected for M1 TOPGUN pre- and posttest for Experiment 1 and 2.

TRAINING OBJECTIVE V
ENGAGE MOVING TARGETS WITH MAIN GUN USING TTS

NOVICE GUNNER

<u>TRIAL</u>	<u>NUMBER & TARGET</u>	<u>TARGET RANGE</u>	<u>TARGET SPEED</u>	<u>TARGET MOVEMENT</u>	<u>KILL ZONE</u>	<u>FIRE COMMAND</u>	<u>AMMO</u>	<u>TIME</u>
<u>STAGE I</u>								
1	1 TANK	12-1300	MOV	FLANK	100%	G-S-MT	APDS	16
2		13-1400						
3		14-1500						
4	1 TANK	12-1300	MOV	FRONTAL	100%	G-S-MT	APDS	16
5		13-1400						
6		14-1500						
7	1 TANK	12-1300	MOV	OBLIQUE	100%	G-S-MT	APDS	16
8		13-1400						
9		14-1500						
<u>STAGE II</u>								
10	1 TANK	15-1600	MOV	FLANK	100%	G-S-MT	APDS	16
11		16-1700						
12		17-1800						
13	1 TANK	15-1600	MOV	FRONTAL	100%	G-S-MT	APDS	16
14		16-1700						
15		17-1800						
16	1 TANK	15-1600	MOV	OBLIQUE	100%	G-S-MT	APDS	16
17		16-1700						
18		17-1800						
<u>STAGE III</u>								
19	1 TANK	18-2000	MOV	FLANK	100%	G-S-MT	APDS	16
20*		20-2200						
21		22-2400						
22*	1 TANK	18-2000	MOV	FRONTAL	100%	G-S-MT	APDS	16
23		20-2200						
24		22-2400						
25	1 TANK	18-2000	MOV	OBLIQUE	100%	G-S-MT	APDS	16
26		20-2200						
27*		22-2400						

Note: Asterisk (*) indicates target engagements selected for M1 TOPGUN pre- and posttest for Experiment 1 and 2.

TRAINING OBJECTIVE VI
ENGAGE MOVING TARGETS WITH MAIN GUN USING GAS

NOVICE GUNNER

<u>TRIAL</u>	<u>NUMBER & TARGET</u>	<u>TARGET RANGE</u>	<u>TARGET SPEED</u>	<u>TARGET MOVEMENT</u>	<u>KILL ZONE</u>	<u>FIRE COMMAND</u>	<u>AMMO</u>	<u>TIME</u>
<u>STAGE I</u>								
1	1 TANK	12-1300	MOV	FLANK	100%	G-S-MT-	APDS	16
2		13-1400				R		
3		14-1500						
4	1 TANK	12-1300	MOV	FRONTAL	100%	G-S-MT-	APDS	16
5		13-1400				R		
6		14-1500						
7	1 TANK	12-1300	MOV	OBLIQUE	100%	G-S-MT-	APDS	16
8		13-1400				R		
9		14-1500						
<u>STAGE II</u>								
10	1 TANK	15-1600	MOV	FLANK	100%	G-S-MT-	APDS	16
11		16-1700				R		
12		17-1800						
13	1 TANK	15-1600	MOV	FRONTAL	100%	G-S-MT-	APDS	16
14		16-1700				R		
15		17-1800						
16	1 TANK	15-1600	MOV	OBLIQUE	100%	G-S-MT-	APDS	16
17		16-1700				R		
18		17-1800						
<u>STAGE III</u>								
19*	1 TANK	18-2000	MOV	FLANK	100%	G-S-MT-	APDS	16
20		20-2200				R		
21		22-2400						
22	1 TANK	18-2000	MOV	FRONTAL	100%	G-S-MT-	APDS	16
23		20-2200				R		
24*		22-2400						
25	1 TANK	18-2000	MOV	OBLIQUE	100%	G-S-MT-	APDS	16
26*		20-2200				R		
27		22-2400						

Note: Asterisk (*) indicates target engagements selected for M1 TOPGUN pre- and posttest for Experiment 1 and 2.

TRAINING OBJECTIVE VII
ENGAGE MULTIPLE TARGETS WITH MAIN GUN USING GPS

NOVICE GUNNER

TRIAL	NUMBER & TARGET	TARGET RANGE	TARGET SPEED	TARGET MOVEMENT	KILL ZONE	FIRE COMMAND	AMMO	TIME
<u>STAGE I</u>								
1	2 TANKS	13-1500	S/S	FNK/FTL	100%	G-S-2T- LT/RT	APDS	28
2	2 TANKS	13-1500	S/S	FTL/FNK	100%	G-S-2T- RT/LT	APDS	28
3	2 TANKS	12-1300	S/S	OBL/FNK	100%	G-S-2T- LT/RT	APDS	28
4	2 TANKS	13-1400	S/S	OBL/FNT	100%	G-S-2T- RT/LT	APDS	28
5	2 TANKS	14-1500	S/S	OBL/OBL	100%	G-S-2T- LT/RT	APDS	28
<u>STAGE II</u>								
6	2 TANKS	16-1800	S/M	FLK/FTL	100%	G-S-2T- LT/MT	APDS	28
7	2 TANKS	16-1800	S/M	FTL/FNK	100%	G-S-2T- RT/MT	APDS	28
8	2 TANKS	15-1600	S/M	OBL/FNK	100%	G-S-2T- LT/MT	APDS	28
9	2 TANKS	16-1700	S/M	OBL/FTL	100%	G-S-2T- RT/MT	APDS	28
10	2 TANKS	17-1800	S/M	OBL/OBL	100%	G-S-2T- LT/MT	APDS	28
<u>STAGE III</u>								
11	2 TANKS	18-2000	M/M	FNK/FNK (LINE)	100%	G-S-2MT- LT/RT	APDS	28
12*	2 TANKS	18-2000	M/M	FTL/FTL (COLUMN)	100%	G-S-2MT- RT/LT	APDS	28
13	2 TANKS	18-2000	M/M	OBL/FNK	100%	G-S-2MT- LT/RT	APDS	28
14*	2 TANKS	20-2200	M/M	OBL/FTL	100%	G-S-2MT- LT/RT	APDS	28
15	2 TANKS	22-2400	M/M	OBL/OBL	100%	G-S-2MT- LT/RT	APDS	28

Note: Asterisk (*) indicates target engagements selected for M1 TOPGUN pre- and posttest for Experiment 1 and 2.

TRAINING OBJECTIVE VIII
ENGAGE MULTIPLE TARGETS WITH MAIN GUN USING TTS

NOVICE GUNNER

TRIALS	NUMBER & TARGET	TARGET RANGE	TARGET SPEED	TARGET MOVEMENT	KILL ZONE	FIRE COMMAND	AMMO	TIME
<u>STAGE I</u>								
1	2 TANKS	13-1500	S/S	FNK/FTL	100%	G-S-2T- LT/RT	APDS	28
2	2 TANKS	13-1500	S/S	FTL/FNK	100%	G-S-2T- RT/LT	APDS	28
3	2 TANKS	12-1300	S/S	OBL/FNK	100%	G-S-2T- LT/RT	APDS	28
4	2 TANKS	13-1400	S/S	OBL/FNT	100%	G-S-2T- RT/LT	APDS	28
5	2 TANKS	14-1500	S/S	OBL/OBL	100%	G-S-2T- LT/RT	APDS	28
<u>STAGE II</u>								
6	2 TANKS	16-1800	S/M	FLK/FTL	100%	G-S-2T- LT/MT	APDS	28
7	2 TANKS	16-1800	S/M	FTL/FNK	100%	G-S-2T- RT/MT	APDS	28
8	2 TANKS	15-1600	S/M	OBL/FNK	100%	G-S-2T- LT/MT	APDS	28
9	2 TANKS	16-1700	S/M	OBL/FTL	100%	G-S-2T- RT/MT	APDS	28
10	2 TANKS	17-1800	S/M	OBL/OBL	100%	G-S-2T- LT/MT	APDS	28
<u>STAGE III</u>								
11*	2 TANKS	18-2000	M/M	FNK/FNK (LINE)	100%	G-S-2MT- LT/RT	APDS	28
12	2 TANKS	18-2000	M/M	FTL/FTL (COLUMN)	100%	G-S-2MT- RT/LT	APDS	28
13*	2 TANKS	18-2000	M/M	OBL/FNK	100%	G-S-2MT- LT/RT	APDS	28
14	2 TANKS	20-2200	M/M	OBL/FTL	100%	G-S-2MT- LT/RT	APDS	28
15	2 TANKS	22-2400	M/M	OBL/OBL	100%	G-S-2MT- LT/RT	APDS	28

Note: Asterisk (*) indicates target engagements selected for M1 TOPGUN pre- and posttest for Experiment 1 and 2.

TRAINING OBJECTIVE IX
ENGAGE MULTIPLE TARGETS WITH MAIN GUN USING GAS

NOVICE GUNNER

TRIAL	NUMBER & TARGET	TARGET RANGE	TARGET SPEED	TARGET MOVEMENT	KILL ZONE	FIRE COMMAND	AMMO	TIME
<u>STAGE I</u>								
1	2 TANKS	13-1500	S/S	FNK/FTL	100%	G-S-2T- LT/RT-R	APDS	28
2	2 TANKS	13-1500	S/S	FTL/FNK	100%	G-S-2T- RT/LT-R	APDS	28
3	2 TANKS	12-1300	S/S	OBL/FNK	100%	G-S-2T- LT/RT-R	APDS	28
4	2 TANKS	13-1400	S/S	OBL/FNT	100%	G-S-2T- RT/LT-R	APDS	28
5	2 TANKS	14-1500	S/S	OBL/OBL	100%	G-S-2T- LT/RT-R	APDS	28
<u>STAGE II</u>								
6	2 TANKS	16-1800	S/M	FLK/FTL	100%	G-S-2T- LT/MT-R	APDS	28
7	2 TANKS	16-1800	S/M	FTL/FNK	100%	G-S-2T- RT/MT-R	APDS	28
8	2 TANKS	15-1600	S/M	OBL/FNK	100%	G-S-2T- LT/MT-R	APDS	28
9	2 TANKS	16-1700	S/M	OBL/FTL	100%	G-S-2T- RT/MT-R	APDS	28
10	2 TANKS	17-1800	S/M	OBL/OBL	100%	G-S-2T- LT/MT-R	APDS	28
<u>STAGE III</u>								
11	2 TANKS	18-2000	M/M	FNK/FNK (LINE)	100%	G-S-2MT- LT/RT-R	APDS	28
12*	2 TANKS	18-2000	M/M	FTL/FTL (COLUMN)	100%	G-S-2MT- RT/LT-R	APDS	28
13	2 TANKS	18-2000	M/M	OBL/FNK	100%	G-S-2MT- LT/RT-R	APDS	28
14*	2 TANKS	20-2200	M/M	OBL/FTL	100%	G-S-2MT- LT/RT-R	APDS	28
15	2 TANKS	22-2400	M/M	OBL/OBL	100%	G-S-2MT- LT/RT-R	APDS	28

Note: Asterisk (*) indicates target engagements selected for M1 TOPGUN pre- and posttest for Experiment 1 and 2.

Legend for Training Objective

Abbreviations

Target

STStationary
MOVMoving
S/STwo Stationary Targets
S/MOne Stationary and One Moving Target
M/M Two Moving Targets
FNK Flank Target
FTLFrontal Target
OBLOblique Target

Fire Command

GGunner
SSabot
TTank
MTMoving Tank
RRange
LTLeft Tank
RTRight Tank
2TTwo Stationary Tanks
2MTTwo Moving Tanks

APPENDIX B

General Instructions to
TOPGUN Subjects

APPENDIX B

General Instructions to TOPGUN Subjects

EXPERIMENT 1 AND 2

You have been selected to participate in training research using a part-task gunnery trainer called TOPGUN. TOPGUN is like most other video-arcade games you may have seen or played except this game involves firing the M1 Abrams tank at simulated enemy targets that appear on a battlefield. Since most of you are not familiar with tank gunnery or the M1 TOPGUN device, you will be given about 15 minutes of classroom instruction on M1 tank gunnery. After that you will be seated in an M1 TOPGUN device where a research assistant will help you use the device to engage and destroy targets. As you train on the device for about ten minutes, you may ask questions and assistance will be provided. Following a short break, you will be reseated in the M1 TOPGUN to complete a 30 target engagement test. Are there any questions?

Before we begin, I want you to read the following Privacy Act statement. (Pause). Are there any problems? If there are no problems, complete the biographical questionnaire that's attached to the statement and return it to me when you are finished.

EXPERIMENT 3

You have been selected to participate in training research using a part-task gunnery trainer called TOPGUN. TOPGUN is like most other video-arcade games you may have seen or played except this game involves firing the M1 Abrams tank at simulated enemy targets that appear on a battlefield. Since all of you are familiar with M1 tank gunnery, you will be seated in an M1 TOPGUN device where a research assistant will help you use the device to engage and destroy tank targets. As you train on the device for about ten minutes, you may ask questions and assistance will be provided. Following a short break, you will be reseated in the M1 TOPGUN to complete a 30 target engagement test. Are there any questions?

Before we begin, I want you to read the following Privacy Act statement. (Pause). Are there any problems? If there are no problems, complete the biographical questionnaire that's attached to the statement and return it to me when you are finished.

PT 5850

APPENDIX C

Soldier Background
Information Questionnaire

APPENDIX C

DATA REQUIRED BY THE PRIVACY ACT OF 1974

AUTHORITY: Title 10, USC, Sec 4503

PRINCIPAL PURPOSE: The data collected with this form are to be used for research purposes only.

ROUTINE PURPOSE: This is an experimental personnel data collection form developed by the U.S. Army Research Institute for the Behavioral and Social Sciences pursuant to its research mission as prescribed in AR 70-1. When identifiers (name or Social Security Number) are requested they are to be used for administrative and statistical control purposes only. Full confidentiality of the responses will be maintained in the processing of these data.

DISCLOSURE: Your participation in this research is strictly voluntary. Individuals are encouraged to provide complete and accurate information in the interests of the research, but there will be no effect on individuals for not providing all or any part of the information.

PT 5850

Soldier Background Information Questionnaire

The purpose of this questionnaire is to collect background information on soldiers participating in the ARI training research on Topgun. This information will be used strictly for research purposes only. Please complete each item to the best of your ability. Write "N/A" for each item you cannot answer.

1. Name: _____
Last First MI
2. Social Security Number: _____-_____-_____
3. Date of Birth: Month ____ Year _____
4. Present Pay Grade/Rank (E-1, E-2, etc.): _____
5. Military Occupational Specialty (MOS): Primary _____
6. Time in the Military: Months _____
7. Time Spent on Tanks: Months _____
8. Time Spent on M1 Tanks: Months: _____
9. Time Spent as an M1 Tank Gunner: Months _____
10. Time Spent as M1 Tank Gunner on U-COFT: Hours _____
11. Number of Times M1 Qualified on Tank Table VIII: _____
12. Highest Level of Civilian Education Completed (Check One):
High School Graduate _____ GED _____
Some College _____ College Graduate _____
Other (specify) _____
13. Have you used the TopGun device before? YES _____ NO _____
If YES, how much time did you spend on TopGun: Hours _____
14. What other gunnery training devices have you used before?
a. _____ b. _____ c. _____ d. _____
e. _____ f. _____ g. _____ h. _____
15. How much time do you think you spent all together on gunnery training devices? Hours _____

PT 5850

APPENDIX D

Soldier Opinion Questionnaire

APPENDIX D

DATA REQUIRED BY THE PRIVACY ACT OF 1974

AUTHORITY: Title 10, USC, Sec 4503

PRINCIPAL PURPOSE: The data collected with this form are to be used for research purposes only.

ROUTINE PURPOSE: This is an experimental personnel data collection form developed by the U.S. Army Research Institute for the Behavioral and Social Sciences pursuant to its research mission as prescribed in AR 70-1. When identifiers (name or Social Security Number) are requested they are to be used for administrative and statistical control purposes only. Full confidentiality of the responses will be maintained in the processing of these data.

DISCLOSURE: Your participation in this research is strictly voluntary. Individuals are encouraged to provide complete and accurate information in the interests of the research, but there will be no effect on individuals for not providing all or any part of the information.

PT 5850

Soldier Opinion Questionnaire

The purpose of this questionnaire is to collect soldiers opinions about the TopGun device they used in the ARI training research. This information will be used strictly for research purposes only. Please complete each question to the best of your ability. Write "NA" for each item you cannot answer.

Part One

We would like to know how much you agree or disagree with each of the following statements. Read each statement carefully then (1) choose the number from the scale below that matches your feelings about the statement, and (2) write the number on the line to the left of the statement. If you have other feelings about TopGun, please write them down in the Comments section.

1	2	3	4	5
Strongly	Somewhat	Neither	Somewhat	Strongly
Disagree	Disagree	Nor Disagree	Agree	Agree

1. _____ I enjoyed training on the TopGun device.
2. _____ When firing at targets, it felt like firing the M1.
3. _____ TopGun helped me improve my tank gunnery skills.
4. _____ Lasing on TopGun is the same as on the M1.
5. _____ If I could see the target, I could hit it.
6. _____ Most of the target engagements were too hard.
7. _____ I had problems identifying the Most Dangerous Threat.
8. _____ I would use TopGun to sustain my gunnery skills.
9. _____ TopGun helped me to engage moving targets.
10. _____ I liked the voice commands for target engagements.
11. _____ I could use TopGun without any instructor assistance.
12. _____ TopGun training will make me a better gunner.
13. _____ I thought the TopGun engagements were too easy.
14. _____ I feel that TopGun scoring is accurate and fair.
15. _____ I had trouble finding the targets on TopGun.
16. _____ I liked the "unity window" for locating targets.

COMMENTS: _____

PT 5850

Part Two

We would like to know how realistic TopGun seems to you. Read each statement carefully then (1) choose the number from the scale below that matches how much TopGun provides a real feeling of the equipment and functions of an M1 tank, and (2) write the number on the line to the left of the statement. If you think TopGun is realistic in other ways, please write them in the Comments section.

1	2	3	4	5
Not At All	Somewhat	Moderately	Very	Extremely
Realistic	Realistic	Realistic	Realistic	Realistic

- 17. _____ Power control handles.
- 18. _____ 3x and 10x sight magnification.
- 19. _____ Laser Rangefinder.
- 20. _____ GPS reticle
- 21. _____ TIS reticles.
- 22. _____ GAS reticle.
- 23. _____ Range data display in sight.
- 24. _____ System status information (Ready-to-fire & "F").
- 25. _____ Visual scenes (targets, background, trees, etc.).
- 26. _____ TC override.
- 27. _____ Fire commands.
- 28. _____ Sight obscuration after firing.
- 29. _____ Automatic lead.
- 30. _____ Sound effects.

COMMENTS: _____

PT 5850

APPENDIX E

General Instructions to
I-COFT Subjects

APPENDIX E

General Instructions to I-COFT Subjects

As soon as the soldiers arrive for testing, meet with them in a group and read the following instructions:

"Good Morning. I am from the U.S. Army Research Institute located here at Fort Knox. You have been selected to participate in training research using the I-COFT and TOPGUN tank gunnery devices. As part of this research we need to know how well you can perform on the I-COFT device before being tested or trained on TOPGUN. For the next one hour, you will complete a total of four exercises under the directions of I-COFT Instructor/Operator (I/Os). Each of the exercises contain 10 target engagements. Prior to the start of any exercise, the I/Os will inform you of any system degradation that might exist for the exercise. They also will instruct you on the switch settings for the exercise and indicate the procedures to be used in that exercise. Are there any questions?"

After this introduction, take them to the particular I-COFTs on which they will be tested and turn them over to the I/Os for further instructions. Make sure the I/Os input the assigned computer data file (OSUT 3988) for the research, the name and rank of the gunner being tested, and the first of the following 4 exercises:

- 332110 - GPS/Sta VS Sta/Multiple Tgts/Short Range
- 333110 - GPS/Sta VS Mov/Multiple Tgts/Short Range
- 313610 - GAS/Sta VS Mov/Single Tgts/Short Range
- 323610 - GAS/Sta VS Mov/Single Tgts/Long Range

Tell the I/Os to conduct the test without providing any feedback to the gunners either during or after their performance. After the first exercise is completed, have the I/Os print out the data for:

- o I-COFT Situation Monitor
- o I-COFT Performance Analysis
- o I-COFT Shot Pattern.

After the data are printed out for the first exercise, have the I/Os load the second exercise and continue I-COFT gunner testing. Follow this testing and data collection procedure for the remaining two Exercises.

As soon as the test is completed by the first 6 soldiers, instruct them to report to Classroom 8 at Skidgel Hall (specify exact time). As soon as the next 6 soldiers complete the test, take them to Classroom 8 at Skidgel Hall.

PT 5850

APPENDIX F

Test Order of Target Engagements
for TOPGUN Pre- and Posttest During Experiment
1 and 2 Combined

APPENDIX F

Test Order Of Target Engagements for TOPGUN Pre- and Posttest During Experiment 1 and 2

<u>Test Order</u>	<u>Engagement</u>	<u>Training Objective and Trial</u>		
1,2,3	Stationary	I-19,	I-23,	1-27
4,5,6		II-21,	II-22,	II-26
7,8,9		III-20,	III-24,	III-25
10,11,12	Moving	IV-21,	IV-23,	IV-25
13,14,15		V-20,	V-22,	V-27
16,17,18		VI-19,	VI-24,	VI-26
19-20,21-22	Multiple	VII-12,	VII-14	
23-24,25-26		VIII-11	VIII-13	
27-28,29-30		IX-12	IX-14	

Note: For target summary description of training objective and trial, refer to Appendix A.

APPENDIX G

Test Order of Target Engagements for Six
Alternate Pre- and Posttest Forms on TOPGUN

APPENDIX G

Test Order of Target Engagements for Six Alternate Pre- and Posttest Forms on TOPGUN

Test Order	Alternate Test Forms					
	1	2	3	4	5	6
1	II-9	I-16	III-26	III-1	I-12	II-20
2	II-16	I-26	III-9	III-16	I-27	II-8
3	II-5	I-15	III-22	III-14	I-22	II-6
4	II-11	I-21	III-1	III-20	I-1	II-12
5	II-22	I-5	III-15	III-6	I-14	II-22
6	II-1	I-11	III-21	III-8	I-16	II-27
7	II-15	I-22	III-5	III-27	I-8	II-16
8	II-21	I-1	III-11	III-22	I-6	II-14
9	II-26	I-9	III-16	III-12	I-20	II-1
10	I-2	III-12	I-19	II-5	III-13	III-24
11	I-12	III-19	I-2	II-11	III-19	III-3
12	I-7	III-17	I-27	II-18	III-26	III-7
13	I-13	III-23	I-6	II-24	III-5	III-13
14	I-27	III-7	I-17	II-7	III-18	III-26
15	I-6	III-13	I-23	II-3	III-11	III-19
16	I-17	III-27	I-7	II-19	III-3	III-11
17	I-23	III-6	I-13	II-26	III-7	III-18
18	I-19	III-2	I-12	II-13	III-24	III-5
19	III-4	II-14	II-24	I-9	II-17	I-25
20	III-14	II-24	II-4	I-15	II-23	I-4
21	III-3	II-10	II-20	I-10	II-21	I-2
22	III-18	II-25	II-8	I-25	II-9	I-17
23	III-20	II-3	II-10	I-2	II-10	I-21
24	III-8	II-18	II-25	I-4	II-15	I-23
25	III-10	II-20	II-3	I-23	II-4	I-15
26	III-25	II-8	II-18	I-21	II-2	I-10
27	III-24	II-4	II-14	I-17	II-25	I-9
28	V-20	IV-12	VI-1	VI-26	IV-16	V-9
29	V-8	IV-27	VI-16	VI-9	IV-26	V-16
30	V-6	IV-22	VI-14	VI-22	IV-15	V-5
31	V-12	IV-1	VI-20	VI-1	IV-21	V-11
32	V-22	IV-14	VI-6	VI-15	IV-5	V-22
32	V-27	IV-16	VI-8	VI-21	IV-11	V-1
34	V-16	IV-8	VI-27	VI-5	IV-22	V-15
35	V-14	IV-6	VI-22	VI-11	IV-1	V-21
36	V-1	IV-20	VI-12	VI-16	IV-9	V-26
37	VI-24	VI-13	V-5	IV-19	VI-12	IV-2
38	VI-3	VI-19	V-11	IV-2	VI-19	IV-12
39	VI-7	VI-26	V-18	IV-27	VI-17	IV-7
40	VI-13	VI-5	V-24	IV-6	VI-23	IV-13
41	VI-26	VI-18	V-7	IV-17	VI-7	IV-27
42	VI-19	VI-11	V-3	IV-23	VI-13	IV-6
43	VI-11	VI-3	V-19	IV-7	VI-27	IV-17
44	VI-18	VI-7	V-26	IV-13	VI-6	IV- 23
45	VI-5	VI-24	V-13	IV-12	VI-2	IV-19

Test Order	Alternate Test Forms					
	1	2	3	4	5	6
46	IV-25	V-17	IV-9	V-24	V-14	VI-4
47	IV-4	V-23	IV-15	V-4	V-24	VI-14
48	IV-2	V-21	IV-10	V-20	V-10	VI-3
49	IV-17	V-9	IV-25	V-8	V-25	VI-18
50	IV-21	V-10	IV-2	V-10	V-3	VI-20
51	IV-23	V-15	IV-4	V-25	V-18	VI-8
52	IV-15	V-4	IV-23	V-3	V-20	VI-10
53	IV-10	V-2	IV-21	V-18	V-8	VI-25
54	IV-9	V-25	IV-17	V-14	V-4	VI-24
55,56	VIII-4	IX-5	VII-3	VIII-5	IX-4	VII-3
57,58	VIII-7	IX-7	VII-6	VIII-7	IX-6	VII-6
59-60	VIII-10	IX-8	VII-9	VIII-9	IX-8	VII-10
61-62	VIII-11	IX-11	VII-11	VIII-12	IX-12	VII-12
63,64	VIII-13	IX-14	VII-15	VIII-13	IX-15	VII-14
65-66	VII-5	VIII-3	IX-4	IX-3	VII-5	IX-5
67,68	VII-6	VIII-6	IX-7	IX-6	VII-7	IX-6
69,70	VII-8	VIII-9	IX-10	IX-10	VII-9	IX-9
71,72	VII-12	VIII-12	IX-12	IX-11	VII-11	IX-12
73,74	VII-14	VIII-15	IX-13	IX-14	VII-13	IX-13
75,76	IX-3	VII-4	VIII-5	VII-4	VIII-3	VIII-4
77,78	IX-7	VII-7	VIII-6	VII-7	VIII-6	VIII-7
79,80	IX-9V	VII-10	VIII-8	VII-8	VIII-10	VIII-8
81,82	IX-11	VII-11	VIII-11	VII-12	VIII-12	VIII-11
83,84	IX-15	VII-13	VIII-14	VII-15	VIII-14	VIII-15

Note: Training objectives and trials are shown in Appendix A.

APPENDIX H

List of Field Modifiable Initialization Parameters (FMIPs)
Modified for the Pre- and Posttest and Training During
Experiments 1 and 2 Combined

APPENDIX H

List of Field Modifiable Initialization Parameters(FMIPs) Modified for the Pre- and Posttest and Training During Experiments 1 and 2 Combined

<u>Number</u>	<u>FMIP</u>	<u>Pre-Posttest</u>	<u>REC Training</u>	<u>FORM Training</u>
3	Playmode	1	0	1
8	Immortality	1	1	1
12	Penalty Pts	0	0	0
14	Game Ammo	54	54	54
18	PTSCC	100,50,0,0	100,50,0,0	100,50,0,0
19	PTSCM	100,50,0,0	100,50,0,0	100,50,0,0
24	PLBPO	0,0	0,0	0,0
26	PLBP1	0,0	0,0	0,0
38	Gun Select	1	1	1
42	Auto Slew	1	1	1
53	Difficulty	0	0	0
54	Plyr Diff Sel	0	0	0
58	PTRNGA	0,1400,2600	0,1400,2600	0,1400,2600
60	PCUDRGM	3	3	3
76	PDWASH	20	20	20
87	Attract	0	0	0
90	Move Ammo Time	0	0	0

Note: All other FMIPs for TOPGUN Software Release Version 1.49 were retained at their default value(s). A definition of the FMIPs and associated values can be obtained by contacting NKH, Inc.

APPENDIX I

List of Field Modifiable Initialization
Parameters (FMIPs) Modified for the Pre-
and Posttest and Training During Experiment 3

APPENDIX I

List of Field Modifiable Initialization Parameters(FMIPs) Modified for the Pre- and Posttest and Training During Experiment 3

<u>Number</u>	<u>FMIP</u>	<u>Pre-Posttest</u>	<u>REC Training</u>	<u>FORM Training</u>
3	Playmode	1	0	1
7	Kill Zone	5	10,8,5	10,8,5
8	Immortality	1	1	1
12	Penalty Pts	0	0	0
14	Game Ammo	54	54	54
18	PTSCC	100,50,0,0	100,50,0,0	100,50,0,0
19	PTSCM	100,50,0,0	100,50,0,0	100,50,0,0
24	PLBPO	0,0	0,0	0,0
26	PLBP1	0,0	0,0	0,0
29	Mult.Ret.Far	35	35	35
30	Mult.Ret.Near	10	10	10
31	Mult.Ret.Range	2200	2200	2200
38	Gun Select	1	1	1
42	Auto Slew	1	1	1
54	Difficulty	0	0	0
55	Plyr Diff Sel	0	0	0
59	PTRNGA	0,1400,2500	0,1400,2500	0,1400,2500
60	PCUORG	3	3	3
77	PDWASH	20	20	20
88	Attract	0	0	0
91	Move Ammo Time	0	0	0

Note: All other FMIPs for TOPGUN Software Release Version 1.50 were retained at their default value(s). A definition of the FMIPs and associated values can be obtained by contacting NKH, Inc.

APPENDIX J

Target Summary Descriptions of
I-COFT Test Exercises

APPENDIX J

Target Summary Descriptions of I-COFT Test Exercises

Training Exercise Number: 332110

Target Presentation Sequence	Target	Range	Motion Speed Direction	View	Gun	Sight	Ammo
1	TANK	940	STATIONARY	FULL LEFT	MAIN	GPS	SABOT
	BMP	940	STATIONARY	FULL LEFT	MAIN	GPS	SABOT
2	HIND	1150	STATIONARY	FULL RIGHT	MAIN	GPS	SABOT
	TANK	1170	STATIONARY	FULL 45/R	MAIN	GPS	SABOT
3	TANK	1360	STATIONARY	FULL 45/R	MAIN	GPS	SABOT
	TRUCK	1440	STATIONARY	FULL 45/R	COAX	GPS	COAX
4	TRUCK	1310	STATIONARY	FULL 45/R	COAX	GPS	COAX
	HIND	1480	STATIONARY	FULL RIGHT	MAIN	GPS	SABOT
5	TANK	1340	STATIONARY	FULL FRONT	MAIN	GPS	SABOT
	HIND	1410	STATIONARY	FULL FRONT	MAIN	GPS	SABOT

Training Exercise Number: 333110

Target Presentation Sequence	Target	Range	Motion Speed Direction	View	Gun	Sight	Ammo
1	TANK	1300	MOV 10MPH	FULL LEFT	MAIN	GPS	SABOT
	BMP	1300	MOV 14MPH	FULL 45/L	MAIN	GPS	SABOT
2	TANK	1320	MOV 14MPH	FULL 45/L	MAIN	GPS	SABOT
	BMP	1300	MOV 15MPH	FULL 45/L	MAIN	GPS	SABOT
3	TANK	1310	MOV 15MPH	FULL 45/R	MAIN	GPS	SABOT
	TANK	1300	MOV 10MPH	FULL RIGHT	MAIN	GPS	SABOT
4	TANK	1300	MOV 16MPH	FULL RIGHT	MAIN	GPS	SABOT
	HIND	1360	MOV 27MPH	FULL RIGHT	MAIN	GPS	SABOT
5	TANK	1300	MOV 15MPH	FULL 45/L	MAIN	GPS	SABOT
	BMP	1300	MOV 18MPH	FULL LEFT	MAIN	GPS	SABOT

Training Exercise Number: 323610

Target Presentation Sequence	Target	Range	Motion Speed Direction	View	Gun	Sight	Ammo
1	TANK	1340	MOV 13MPH	FULL LEFT	MAIN	GAS	SABOT
2	TANK	1350	MOV 15MPH	FULL 45/R	MAIN	GAS	SABOT
3	BMP	1370	MOV 20MPH	FULL 45/R	MAIN	GAS	SABOT
4	TANK	1340	MOV 17MPH	FULL 45/R	MAIN	GAS	SABOT
5	HIND	1500	MOV 20MPH	FULL RIGHT	MAIN	GAS	SABOT
6	TANK	1100	MOV 12MPH	FULL RIGHT	MAIN	GAS	SABOT
7	TRUCK	960	MOV 16MPH	FULL 45/R	COAX	GAS	COAX
8	TRUCK	470	MOV 25MPH	FULL RIGHT	COAX	GAS	COAX
9	BMP	1370	MOV 15MPH	FULL FRONT	MAIN	GAS	SABOT
10	TANK	1400	MOV 16MPH	FULL 45/R	MAIN	GAS	SABOT

Training Exercise Number: 313610

Target Presentation Sequence	Target	Range	Motion Speed Direction	View	Gun	Sight	Ammo
1	TANK	900	MOV-11MPH	FULL LEFT	MAIN	GAS	SABOT
2	TANK	1350	MOV-12MPH	FULL 45/R	MAIN	GAS	SABOT
3	BMP	960	MOV-11MPH	FULL LEFT	MAIN	GAS	SABOT
4	TANK	1350	MOV-18MPH	FULL 45/R	MAIN	GAS	SABOT
5	HIND	1070	MOV-19MPH	FULL RIGHT	MAIN	GAS	SABOT
6	TANK	1200	MOV-18MPH	FULL 45/L	MAIN	GAS	SABOT
7	TRUCK	970	MOV-17MPH	FULL 45/R	COAX	GAS	COAX
8	TRUCK	990	MOV-15MPH	FULL 45/R	COAX	GAS	COAX
9	BMP	1350	MOV-15MPH	FULL 45/R	MAIN	GAS	SABOT
10	TANK	1370	MOV-15MPH	FULL FRONT	MAIN	GAS	SABOT

Note: Engagements fired by the gunner using either the coaxial machinegun (COAX) or HEAT ammunition were excluded from the gunner's I-COFT pre- and posttest scores.

APPENDIX K

Sight Switch Settings for Pre- and Posttest
on TOPGUN During Experiment 1 and 2 Combined

APPENDIX K

Sight Switch Settings for Pre- and Posttest on TOPGUN During Experiment 1 and 2 Combined

<u>Target Engagement Number</u>	<u>Number Of Targets Presented</u>	<u>Sight Switch Settings</u> <u>Type of Target</u>		
		<u>Stationary</u>	<u>Moving</u>	<u>Multiple</u>
#1-3	3	GPS	...	...
4-6	3	TTS	...	...
7-9	3	GAS	...	...
#10-12	3	...	GPS	...
13-15	3	...	TTS	...
16-18	3	...	GAS	...
#19-22	4	...	...	GPS
23-26	4	...	...	TTS
27-30	4	...	...	GAS

APPENDIX L

Sight Switch Settings For Alternate
Pre- and Posttest Forms on TOPGUN

APPENDIX L

Sight Switch Settings for Six Alternate Pre- and Posttest Forms on TOPGUN

Target Type/ Engagement Number	Number Of Targets Presented	Sight Switch Settings Alternate Forms					
		<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>
<u>STATIONARY</u>							
# 1-9	9	TTS	GPS	GAS	GAS	GPS	TTS
10-18	9	GPS	GAS	GPS	TTS	GAS	GPS
19-27	9	GAS	TTS	TTS	GPS	TTS	GAS
<u>MOVING</u>							
# 1-9	9	GAS	GPS	GAS	GAS	GPS	TTS
10-18	9	TTS	GAS	TTS	GPS	GAS	GPS
19-27	9	GPS	TTS	GPS	TTS	TTS	GAS
<u>MULTIPLE</u>							
# 1-5	10	TTS	GAS	GPS	TTS	GAS	GPS
6-10	10	GPS	TTS	GAS	GAS	GPS	GAS
11-15	10	GAS	GPS	TTS	GPS	TTS	TTS

APPENDIX M

Summary of Biographical Data for Soldiers
in Experiments 1 and 2 Combined

APPENDIX M

Summary of Biographical Data for Soldiers in Experiments 1 and 2 Combined

1.	Mean Age	<u>27.19 yrs</u>	Range	<u>22 - 37 yrs</u>
2.	Grade	E6 <u>23</u>	O1	<u>24</u>
3.	MOS	19D <u>23</u>	Specialty Code	<u>24</u>
4.	Mean Months in Service	<u>76.95</u>	Range	<u>1 - 264</u>
5.	Mean Months on Tanks	<u>2.10</u>	Range	<u>0 - 24</u>
6.	Mean Months on M1 Tanks	<u>0.00</u>		
7.	Mean Months as M1 Gunner	<u>0.00</u>		
8.	Mean Hours as M1 U-COFT Gunner	<u>0.11</u>	Range	<u>0 - 4</u>
9.	Mean Time M1 TT VIII Qualified	<u>0.00</u>		
10.	Education Level	High School graduate	<u>7</u>	
		GED	<u>1</u>	
		Some College	<u>15</u>	
		College graduate	<u>24</u>	
		Other	<u>0</u>	
11.	Mean TOPGUN Experience	<u>0.00</u>		
12.	Mean Hours on TOPGUN	<u>0.00</u>		
13.	Mean Training Devices Used	<u>.86</u>	Range	<u>0 - 7</u>
14.	Mean Hours on Gunnery Devices	<u>28.62</u>	Range	<u>0 - 400</u>

Appendix N
Data Tables for Experiments 1 and 2
Combined

Table N-1

Correlation Matrices for TOPGUN Pretest and Posttest Performance Measures in Experiments 1 and 2 Combined

<u>Pretest</u>						
	<u>% FRDHT</u>	<u>% TGHIT</u>	<u>RDS/TGT</u>	<u>% HITS</u>	<u>F-RATE</u>	<u>H-RATE</u>
<u>% FRDHT</u>	1.0000	.8490**	.8686**	.9589**	.1318	.8617**
<u>% TGHIT</u>	.8490**	1.0000	-.6182**	.8911**	.4594**	.9344**
<u>RDS/TGT</u>	-.8686**	-.6182**	1.0000	-.8773**	.2066	-.6595**
<u>% HITS</u>	.9589**	.8911**	-.8773**	1.0000	.1111	.8759**
<u>F-RATE</u>	.1318	.4594**	.2066	.1111	1.0000	.5552**
<u>H-RATE</u>	.8617**	.9344**	-.6595**	.8759**	.5552	1.0000
<u>Posttest</u>						
	<u>% FRDHT</u>	<u>% TGHIT</u>	<u>RDS/TGT</u>	<u>% HITS</u>	<u>F-RATE</u>	<u>H-RATE</u>
<u>% FRDHT</u>	1.0000	.8288**	-.8873**	.9423**	-.0074	.6906**
<u>% TGHIT</u>	.8288**	1.0000	-.7195**	.9027**	.3605*	.8877**
<u>RDS/TGT</u>	-.8873**	-.7195**	1.0000	-.9143**	.1446	-.6089**
<u>% HITS</u>	.9423**	.9027**	-.9143**	1.0000	.0576	.7720**
<u>F-RATE</u>	-.0074	.3605	.1446	.0576	1.0000	.6623**
<u>H-RATE</u>	.6906**	.8877**	-.6089**	.7720**	.6623*	1.0000

Note: % FRDHT = Percentage of First Round Hits; % TGHIT = Percentage of Targets Hit; RDS/TGT = Rounds Per Target; % HITS = Percentage of Hits; F-RATE = Firing Rate; H-RATE = Hit Rate.

* = $p < .01$, ** = $p < .001$, and all probabilities are one-tailed.

Table N-2

Mean Questionnaire Responses From Cavalry Scout 19D ANCOB
Soldiers and Pre-AOB Officers Combined

Part 1: Items		Rating
No.	Strongly Disagree (1) to Strongly Agree (5)	Training Groups (N=30)
1.	I enjoyed training on the TOPGUN device.	4.75
2.	When firing at targets, it felt like firing the M1.	N/A
3.	TOPGUN helped me improve my tank gunnery skills.	4.10
4.	Lasing on TOPGUN is the same as on the M1.	N/A
5.	If I could see the target, I could hit it.	4.29
6.	Most of the target engagements were too hard. ^a	4.41
7.	I had problems identifying the Most Dangerous Threat. ^a	4.62
8.	I would use TOPGUN to sustain my gunnery skills.	4.11
9.	TOPGUN helped me to engage moving targets.	4.41
10.	I liked the voice commands for target engagements.	4.21
11.	I could use TOPGUN without any instructor assistance.	4.17
12.	TOPGUN training will make me a better gunner.	4.36
13.	I thought the TOPGUN engagements were too easy.	3.07
14.	I feel that TOPGUN scoring is accurate and fair.	4.28
15.	I had trouble finding the targets on TOPGUN. ^a	4.59
16.	I liked the "unity window" for locating targets.	3.73

^aScale is reversed; high numbers represent positive attitude.

APPENDIX 0

Summary of Biographical Data for M1 Armor
Crewmen in Experiment 3

APPENDIX O

Summary of Biographical Data for Armor Crewmen in Experiment 3

1.	Mean Age	<u>24.83 yrs</u>	Range	<u>21 - 39 yrs</u>
2.	Grade	E-4 <u>19</u> E-5 <u>15</u> E-6 <u>2</u>		
3.	MOS	19K <u>36</u>		
4.	Mean Months in Service	<u>66.44</u>	Range	<u>24 - 144</u>
5.	Mean Months on Tanks	<u>49.81</u>	Range	<u>2 - 124</u>
6.	Mean Months on M1 Tanks	<u>17.14</u>	Range	<u>1 - 72</u>
7.	Mean Months as M1 Gunner	<u>6.50</u>	Range	<u>0 - 48</u>
8.	Mean Hours as M1 U-COFT Gunner	<u>21.25</u>	Range	<u>0 - 165</u>
9.	Mean Time M1 TT VIII Qualified	<u>1.14</u>	Range	<u>0 - 9</u>
10.	Education Level	High School graduate <u>23</u>		
		GED <u>3</u>		
		Some College <u>10</u>		
		College graduate <u>0</u>		
		Other <u>0</u>		
11.	Mean TOPGUN Experience	<u>0.22</u>	Range	<u>0 - 1</u>
12.	Mean Hours on TOPGUN	<u>0.72</u>	Range	<u>0 - 10</u>
13.	Mean Training Devices Used	<u>1.86</u>	Range	<u>0 - 6</u>
14.	Mean Hours on Gunnery Devices	<u>90.64</u>	Range	<u>0 - 400</u>

Appendix P
Data Tables for Experiment 3

Table P-1

Correlation Matrices for TOPGUN Pretest and Posttest Performance Measures in Experiment 3

<u>Pretest</u>						
	<u>% FRDHT</u>	<u>% TGHIT</u>	<u>RDS/TGT</u>	<u>% HITS</u>	<u>F-RATE</u>	<u>H-RATE</u>
<u>% FRDHT</u>	1.0000	.6788**	-.8817**	.9113**	.1894	.6214**
<u>% TGHIT</u>	.6788**	1.0000	-.5122**	.7970**	.4989**	.7795**
<u>RDS/TGT</u>	-.8817**	-.5122**	1.0000	-.9125**	-.1454	-.5973**
<u>% HITS</u>	.9113**	.7970**	-.9125**	1.0000	.3260	.7655**
<u>F Rate</u>	.1894	.4989**	-.1454	.3260	1.0000	.8241**
<u>H Rate</u>	.6214**	.7795**	-.5973**	.7655**	.8241**	1.0000

<u>Posttest</u>						
	<u>% FRDHT</u>	<u>% TGHIT</u>	<u>RDS/TGT</u>	<u>% HITS</u>	<u>F-RATE</u>	<u>H-RATE</u>
<u>% FRDHT</u>	1.0000	.5431**	-.7823**	.8061**	.1643	.5384**
<u>% TGHIT</u>	.5431**	1.0000	-.5262**	.7775**	.4184*	.7424**
<u>RDS/TGT</u>	-.7823**	-.5262**	1.0000	-.9344**	.0464	-.4815*
<u>% HITS</u>	.8061**	.7775**	-.9344**	1.0000	.1470	.6495**
<u>F Rate</u>	.1643	.4184*	.0464	.1470	1.0000	.8213**
<u>H Rate</u>	.5384**	.7424**	-.4815*	.6495**	.8213**	1.0000

Note: % FRDHT = Percentage of First Round Hits; % TGHIT = Percentage of Targets Hit; RDS/TGT = Rounds Per Target; % HITS = Percentage of Hits; F-RATE = Firing Rate; H-RATE = Hit Rate.

* = $p < .01$, ** = $p < .001$, and all probabilities are one-tailed.

Table P-2

Correlation Matrices for I-COFT Pretest and Posttest Performance Measures in Experiment 3

<u>Pretest</u>						
	<u>% FRDHT</u>	<u>% TGHIT</u>	<u>RDS/TGT</u>	<u>% HITS</u>	<u>F-RATE</u>	<u>H-RATE</u>
<u>% FRDHT</u>	1.0000	.8855**	-.5473**	.9553**	.1995	.8087**
<u>% TGHIT</u>	.8855**	1.0000	-.4280*	.8753**	.2655	.8306**
<u>RDS/TGT</u>	-.5473**	-.4280*	1.0000	-.5768**	.1199	-.3920*
<u>% HITS</u>	.9553**	.8753**	-.5768**	1.0000	.1628	.8194**
<u>F Rate</u>	.1995	.2655**	-.1199	.1628	1.0000	.6315**
<u>H Rate</u>	.8087**	.8306**	-.3920*	.8194**	.6315**	1.0000
<u>Posttest</u>						
	<u>% FRDHT</u>	<u>% TGHIT</u>	<u>RDS/TGT</u>	<u>% HITS</u>	<u>F-RATE</u>	<u>H-RATE</u>
<u>% FRDHT</u>	1.0000	.8540**	-.2094	.9272**	-.0496	.6223**
<u>% TGHIT</u>	.8540**	1.0000	-.0147	.9104**	.2110	.8354**
<u>RDS/TGT</u>	-.2094	-.0147	1.0000	-.2592	.2574	-.0528
<u>% HITS</u>	.9272**	.9104**	-.2592	1.0000	.0431	.7763**
<u>F Rate</u>	-.0496	.2110	.2574	.0431	1.0000	.5715**
<u>H Rate</u>	.6223**	.8354**	-.0528	.7763**	.5715**	1.0000

Note: % FRDHT = Percentage of First Round Hits; % TGHIT = Percentage of Targets Hit; RDS/TGT = Rounds Per Target; % HITS = Percentage of Hits; F-RATE = Firing Rate; H-RATE = Hit Rate.

* = $p < .01$, ** = $p < .001$, and all probabilities are one-tailed.

Table P-3

Mean Questionnaire Responses From 19K Soldiers

No.	Part 1: Items Strongly Disagree (1) to Strongly Agree (5)	Rating	
		Rec (n=10)	Form (n=11)
1.	I enjoyed training on the TOPGUN device.	4.80	4.42
2.	When firing at targets, it felt like firing the M1.	3.60	3.17
3.	TOPGUN helped me improve my tank gunnery skills.	4.70*	3.75
4.	Lasing on TOPGUN is the same as on the M1.	3.90	3.50
5.	If I could see the target, I could hit it.	3.90	4.17
6.	Most of the target engagements were too hard. ^a	4.10*	4.75
7.	I had problems identifying the Most Dangerous Threat. ^a	4.30	3.75
8.	I would use TOPGUN to sustain my gunnery skills.	4.70*	3.67
9.	TOPGUN helped me to engage moving targets.	4.60	4.00
10.	I liked the voice commands for target engagements.	4.40*	3.25
11.	I could use TOPGUN without any instructor assistance.	4.10	4.58
12.	TOPGUN training will make me a better gunner.	4.60	3.75
13.	I thought the TOPGUN engagements were too easy.	3.50	4.50
14.	I feel that TOPGUN scoring is accurate and fair.	4.00	3.92
15.	I had trouble finding the targets on TOPGUN. ^a	4.50	4.75
16.	I liked the "unity window" for locating targets.	4.50	4.08

^aScale is reversed; high numbers represent positive attitude.

*p < .05

Table P-3 (Continued)

No.	Part 2: Items Not Realistic (1) To Extremely Realistic (5)	Rating	
		Rec (n=10)	Form (n=11)
17.	Power Control Handles.	3.80	3.73
18.	3x and 10x Sight Magnification.	4.00	3.64
19.	Laser Rangefinder.	4.30*	3.09
20.	GPS Reticle.	4.50	3.55
21.	TIS Reticle.	4.50*	3.55
22.	GAS Reticle.	4.60	3.27
23.	Range Data Display In Sight.	4.40	3.82
24.	System Status Information (Ready-to-Fire & "F").	4.40	4.00
25.	Visual Scenes (Targets, Background, Trees, Etc.).	4.60	3.91
26.	TC Override.	4.40	4.36
27.	Fire Commands.	4.70*	3.91
28.	Sight Obscuration After Firing.	3.00	2.91
29.	Automatic Lead.	4.11	2.91
30.	Sound Effects.	4.11	3.18

* $p < .05$