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Effectiveness of the AH-1 Flight and Weapons Simulator for Sustaining Aerial Gunnery Skills

D. Michael McAnulty
Anacapa Sciences, Inc.

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This report evaluates the effectiveness of the AH-1 Flight and Weapons Simulator (FWS) for sustaining crew gunnery proficiency in the AH-1F helicopter. Following an initial live-fire exercise, the participating AH-1 crews were assigned to one of three groups. The control group continued normal unit training but was restricted from gunnery practice in the FWS. Both experimental groups were restricted in gunnery practice in the aircraft but were required to receive either quarterly or monthly gunnery training in the FWS. The gunnery performance of the participating crews was evaluated at a final live-fire exercise 15 months after the initial exercise. The results indicate that the FWS is moderately effective in sustaining crew gunnery proficiency: Compared with the control group crews during the final exercise, the experimental group crews exhibited improved first-run performance and required fewer runs, engagements, and rockets to qualify. The results are very similar for the 20-mm gun, 2.75-inch rocket, and tube-launched, optically sighted, wire-guided (TOW) missile weapon systems. The results indicate that quarterly training is as effective as monthly training for sustaining aerial gunnery skills,

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Research Report 1612

Effectiveness of the AH-1 Flight and Weapons Simulator for Sustaining Aerial Gunnery Skills

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FOREWORD

The U.S. Army has made a significant investment in developing and acquiring motion-based, visual flight simulators for its rotary wing aircraft. The primary function of the Army's flight simulators is to sustain aircrew skills in operational aviation units. However, little empirical data exist to document the training effectiveness of the simulators or to guide the development of programs of instruction that provide the maximum benefit for flight simulator training.

This research is part of a series of experiments conducted by the U.S. Army Research Institute Fort Rucker Field Unit at the U.S. Army Aviation Center (USAAVNC), Fort Rucker, Alabama, to investigate the effectiveness and optimization of flight simulator training. The research program was initiated by a Memorandum of Agreement between the USAAVNC and the Fort Rucker Field Unit dated 15 March 1984, as part of the task entitled "Techniques for Enhancing Aviation Unit Combat Readiness." The experiment reported in this document is part of the mission of the Training Systems Research Division of the U.S. Army Research Institute for the Behavioral and Social Sciences. The research was also designed to address questions raised by the Deputy Chief of Staff for Operations and Plans, Training Directorate; the Standards in Training Commission (STRAC); and the Department of Tactics and Simulation (DOTS, formerly the Department of Gunnery and Flight Simulation) at the USAAVNC.

The results of this experiment indicate that the AH-1 Flight and Weapons Simulator (FWS) is moderately effective in sustaining crew gunnery proficiency if well-developed scenarios are used for training. The results also indicate that quarterly FWS training is as effective as monthly training.

The results of this experiment have been briefed to representatives from STRAC, the USAAVNC command group, DOTS, and the Directorate of Training and Doctrine at the USAAVNC. The information obtained from this research supports the use of the FWS for gunnery sustainment training and provides guidance about the optimal use of the simulator. The data also provide empirical information about the ammunition needed for AH-1 gunnery training and the standards for crew qualification. Finally, nine training scenarios developed for this project are available for use by aviation units and simulator facilities.

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Several persons at the U.S. Army Research Institute for the Behavioral and Social Sciences Fort Rucker Field Unit and Anacapa Sciences, Inc., at Fort Rucker, Alabama, contributed to this project. Thomas Longridge (Fort Rucker) and George Kaempf (Anacapa) were primarily responsible for the initial research design; Dr. Kaempf also initiated the data collection and simulator training efforts. Joan Blackwell and William Howse (Fort Rucker) participated in the on-site training and data collection; Ms. Blackwell also provided administrative coordination for the acquisition of ammunition and the retention of participating aviators. Chris Rummel (Anacapa) served as a subject matter expert, on-site researcher, simulator instructor/operator, and data processor.

Larry Murdock (Fort Rucker) was responsible for developing data entry programs and conducting the statistical analyses. Five other Anacapa staff members supported the project. Nadine McCollim was primarily responsible for processing the written and graphic materials, Ernestine Pridgen provided administrative and proofreading support, and Annette Swan provided data entry and document preparation support. David Hamilton consulted on the analysis and presentation of the data. Finally, Kenneth Cross provided guidance in developing and conducting the research and editorial support in producing the report.

Although it is not possible to acknowledge them all individually, the author thanks the unit commanders, instructor pilots, and aviators who participated in this research. Special thanks are extended to Chief Warrant Officer W-4 Ron Clary and Chief Warrant Officer W-4 Tim Bliss, officers-in-charge of the participating simulator facilities, and their staffs for supporting the simulator training. Finally, the author thanks and applauds Captain Art Lauer, 7th Army Training Command, for his dedicated and unflagging efforts to coordinate and obtain resources for this research project.

EFFECTIVENESS OF THE AH-1 FLIGHT AND WEAPONS SIMULATOR FOR SUSTAINING AERIAL GUNNERY SKILLS

EXECUTIVE SUMMARY

Requirement:

The U.S. Army has developed and acquired sophisticated motion-based, visual flight simulators to support the training of its rotary wing aviators. Most of the Army flight simulators are used by the major commands for conducting refresher, enrichment, and sustainment training of operational unit aviators. However, little empirical data exist to document the training effectiveness of these simulators or to guide the development of programs of instruction to obtain the maximum benefit from flight simulator training.

The primary objective of this experiment was to determine the effectiveness of the AH-1 Flight and Weapons Simulator (FWS) for sustaining crew gunnery skills. In addition, the research was designed to (a) compare the effectiveness of different amounts of FWS training for sustaining gunnery skills, (b) estimate the ammunition requirements for crew gunnery qualification, and (c) evaluate the Army standards for crew gunnery qualification.

Procedure:

A forward transfer-of-training design was used to address the research objectives. Operational crews assigned to units of the U.S. Army, Europe (USAREUR), were pretested on their prior flight experience, knowledge of the AH-1 weapon systems, and gunnery proficiency during an initial live-fire exercise. The crews were then assigned to either the control group, the quarterly FWS training group, or the monthly FWS training group.

The control group crews continued with their normal unit training in the aircraft but were restricted from gunnery practice in the FWS. The experimental group crews received either quarterly or monthly gunnery training in the FWS but were restricted on their gunnery training in the aircraft; there were no restrictions on their aircraft training other than gunnery. The crews' gunnery performance was assessed again during a final live-fire exercise conducted approximately 15 months after the initial exercise.

Findings:

The results indicate that the FWS is moderately effective in sustaining crew gunnery proficiency: Compared with the control group crews during the final exercise, the experimental group crews achieved improved first-run performance and required fewer runs, rockets, and engagements to qualify. The FWS training had a greater effect on the accuracy of the crews' gunnery performance than on the speed of conducting the engagement. The results are very similar for the 20-mm gun, 2.75-inch rocket, and tube-launched optically sighted, wire-guided (TOW) missile weapon system.

The results also indicate that quarterly training is as effective as monthly training for sustaining aerial gunnery skills, but questions remain about the effect of recency of training. Finally, the data were used to estimate ammunition requirements and to evaluate established standards for AH-1 crew qualification. The established ammunition allocations are near the minimum for sustaining crew gunnery skills and may be insufficient if the established Army-wide criteria for crew qualification are enforced. The results indentified two limitations in the USAREUR qualification table but generally supported the criteria established in the current helicopter gunnery manual (Training Circular 1-140, 1990).

Utilization of Findings:

Although additional research is needed, the findings of this experiment support five recommendations about AH-1 gunnery sustainment training. First, attack helicopter units should augment their aviator training program with structured FWS gunnery training, but simulator training should not replace live-fire exercises. Second, aviation units should routinely schedule FWS gunnery training for each crew, preferably once a quarter and at least within 1 month of a live-fire exercise; more frequent training can be conducted for less experienced or less proficient crews. Third, well-developed scenarios should be used to obtain the maximum benefit from the FWS training. Fourth, the ammunition allocated for AH-1 gunnery training should not be substantially reduced from current levels. Fifth, both USAREUR and the U.S. Army Aviation Center (USAAVNC) should reevaluate the standards imposed for qualification and their implications for training and training resources.

The nine training scenarios developed for this project are available for use by aviation units and simulator facilities.

EFFECTIVENESS OF THE AH-1 FLIGHT AND WEAPONS SIMULATOR FOR SUSTAINING AERIAL GUNNERY SKILLS

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GLOSSARY OF ACRONYMS AND ABBREVIATIONS

AAA	Army Audit Agency
ANOVA	Analysis of Variance
AQC	Aviator Qualification Course
CALFEX	Combined Arms Live-Fire Exercise
CH47FS	CH-47 Flight Simulator
CMS	Combat Mission Simulator
CPG	Copilot/Gunner
CRISP	Computer Regenerated Images from Scene Photographs
DOTS	Department of Tactics and Simulation
ETM	Emergency Touchdown Maneuver
FARP	Forward Arming and Refueling Point
FM	Field Manual
FWS	Flight and Weapons Simulator
GHS	Gunner's Helmet Sight
HE	High Explosive
HS	Helmet Sight
I/O	Instuctor/Operator
IP	Instructor Pilot
LIG	Laser Image Generation
MPSM	Multipurpose Submunition
PHS	Pilot's Helmet Sight
SIP	Standardization Instructor Pilot
STRAC	Standards in Training Commission
TC	Training Circular
TEA	Training Effectiveness Analysis
TEP	Target Engagement Point
TOW	Tube-Launched, Optically Sighted, Wire-Guided
TSU	Telescopic Sight Unit
UH60FS	UH-60 Flight Simulator
USAAVNC	U.S. Army Aviation Center
USAREUR	U.S. Army, Europe

EFFECTIVENESS OF THE AH-1 FLIGHT AND WEAPONS SIMULATOR FOR SUSTAINING AERIAL GUNNERY SKILLS

Introduction

Early flight simulators consisted of a generic cockpit in an airframe mockup. They had only a limited number of functional components and did not provide any external visual references. Since their introduction in 1929, such relatively simple, generic simulators have been shown to be highly effective in training initial instrument, navigation, and aircraft handling skills (e.g., Caro, Isley, & Jolley, 1973). Compared to the use of aircraft for training, flight simulators are usually less expensive to operate and maintain, are more available (e.g., when weather prevents aircraft flight), contain more instructional features (e.g., freeze and replay), can present flight conditions that are excessively hazardous in the aircraft (e.g., emergency procedures), and provide practice on tasks that are extremely expensive in the aircraft (e.g., gunnery practice).

As aircraft have increased in sophistication, so have the simulators that are designed to support them. Modern flight simulators resemble specific aircraft, have high technology visual and motion systems supported by extensive aerodynamic modeling, and present dynamic flight environments that include other aircraft, land vehicles, navigational aids, and military threats. Modern simulators are used for both acquisition and sustainment training of individual, crew, and team skills for visual, instrument, emergency, and weapon tasks. In addition, they are used to conduct Federal Aviation Administration checkrides, to evaluate aircraft design options, and to conduct basic and applied research (Stark, 1989).

The value of simulators for flight training has been demonstrated repeatedly, especially for the acquisition of basic flight skills (e.g., Caro, 1988; Sticha, Blacksten, Knerr, Morrison, & Cross, 1986). Despite the many experiments that have evaluated simulator training effectiveness, many questions remain about the relevant processes of human learning, the requirements for simulator fidelity, the types of skills and tasks that can be trained, the optimal instructional strategies to employ, and the generalizability of training transfer results (Caro, 1988; Cross & Gainer, 1987; Stark, 1989). Orlansky and String (1977) concluded that, although flight simulators are useful for training pilots and other crewmembers on a wide variety of flight skills, previous research has provided only limited guidance in the optimum design and use of the simulators.

There is even less information available about the design, effectiveness, and use of flight simulators for helicopter training because most of the research has been conducted with fixed-wing aircraft simulators (Jacobs, Prince, Hays, & Salas, 1990).

A major practical and theoretical concern is whether skills that can be acquired effectively in the simulator can also be sustained in the simulator. Low cost, low fidelity simulators that present limited cues and response options can be used effectively to train basic flight skills, but more complex tasks performed by experienced aviators probably require more complex training devices (Caro, 1988). That is, experienced aviators may utilize more cues and employ more responses than novice aviators in flying the aircraft and, consequently, may need more cues and response opportunities in the simulator to sustain their high skill levels.

The effectiveness of simulators for skill sustainment has not been thoroughly researched, primarily because of the greater difficulty in measuring skill sustainment compared to skill acquisition. As skills are acquired, task performance changes rapidly and is relatively easy to measure. Conversely, aviation skills decay very slowly (Cross & Gainer, 1987; Prophet, 1976; Ruffner & Bickley, 1983) and may be maintained by practice on similar tasks; thus, skill decay and sustainment are more difficult to measure than skill acquisition. There are also operational readiness and ethical problems with limiting training for control group aviators until their skills are measurably degraded, a necessary condition for demonstrating that the simulator can sustain those skills. Despite the possible differences in the effectiveness of simulators for training and checking the proficiency of experienced aviators, simulators are being widely used for these purposes in commercial and military settings (Caro, 1988).

U.S. Army Flight Simulators

During the past two decades, the U.S. Army has made a significant investment in the development and acquisition of motion-based, visual flight simulators for its rotary wing aircraft. As training resources have become scarce and the competition for those resources has become intense, high-fidelity flight simulators have been viewed as effective alternatives to aircraft flight training. The Army has purchased and fielded visual flight simulator systems for the AH-1F, AH-64A, CH-47D, and UH-60A helicopters.

The majority of the simulators are used by operational aviation units for refresher, enrichment,[1] and sustainment training. Currently, there are 7 AH-1F Flight and Weapons Simulators (FWSs), 6 AH-64A Combat Mission Simulators (CMSs), 6 CH-47D Flight Simulators (CH47FSs), and 15 UH-60A Flight Simulators (UH60FSs) distributed among the major Army commands. Six more CMSs are planned for distribution to field units in the near future. In addition, there are two FWSs, one CMS, one CH47FS, and two UH60FSs located at the U.S. Army Aviation Center (USAAVNC) that are used for both initial entry and transition training.

Army Flight Simulator Research

Prior to the purchase and dispersal of the simulators to operational units, the Army sponsored several research projects designed to investigate the training effectiveness of the prototype systems. The primary purpose of these projects was to determine the effectiveness of the respective flight simulator when incorporated into a program of instruction for institutional training. Some of the research projects attempted to evaluate the effectiveness of the simulators for sustainment training, but with limited success.

Holman (1979) conducted two experiments to evaluate the effectiveness of the CH47FS. In the first experiment, 24 CH-47C transition students were trained to proficiency on 32 flight tasks in the CH47FS while 35 students were trained to proficiency in the aircraft. The simulator-trained students were then trained to proficiency in the aircraft. The results indicated that the CH47FS was effective for initial training of all the tasks except those that involved extensive ground referencing (e.g., hovering), terrain flight, and night operations.

In the second experiment, Holman (1979) divided 32 qualified and current CH-47C pilots into an experimental and a control group. Each of the 16 experimental group aviators received 30 hours of CH47FS training and an average of 45.2 hours of mission essential flying in the CH-47C over a 6-month period. Each of the 16 control group aviators received no simulator training but flew an average of 58.0 mission

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[1]Enrichment training involves developing new skills or improving basic skills. It is analagous to skill acquisition training in the school environment.

hours in the CH-47C during the same period. All the aviators received pretest and posttest checkrides in the aircraft on 35 flight tasks.

Holman (1979) found that the performance of the simulator trained aviators improved significantly from the pretest to the posttest and that there was no significant difference between the two groups on the posttest checkride. Holman attributed the improved posttest checkride scores for the experimental group aviators to simulator training alone and concluded that the CH47FS was effective for sustaining flight skills.

Despite the use of a control group, Holman's (1979) conclusion is misleading because he did not equate the two groups for previous flight experience or flight proficiency: The pretest checkride scores were significantly higher for the control group aviators than for the experimental group aviators. In addition, there was no evidence of skill decay in the control group. Basic flight skills generally do not degrade over a 6-month period (Prophet, 1976; Ruffner & Bickley, 1983; Smith & Matheny, 1976), and all the aviators flew enough mission hours to sustain their basic skills. The Holman results actually indicate that skills can be acquired in the simulator; whether skills can be sustained in the simulator was unresolved.

Bridgers, Bickley, and Maxwell (1980) conducted two similar experiments in the FWS. In the first experiment, AH-1 transition students (number unspecified) were assigned to experimental and control groups. The control group aviators were trained in the AH-1; the experimental group aviators were first trained in the FWS and then trained in the aircraft. Bridgers et al. reported positive forward transfer from the FWS to the aircraft for most of the tasks trained in the AH-1 Aviator Qualification Course (AQC). The results of this experiment also supported the use of flight simulators for skill acquisition in the institutional environment.

In the second experiment, 12 operational unit aviators were given a pretest checkride on 3 gunnery and 16 contact flight tasks in the AH-1 aircraft. The aviators were then trained on the 19 tasks in the FWS; each aviator received an average of 6.4 FWS sessions during the 2-week training period. Subsequently, the aviators were given a posttest checkride in the AH-1 aircraft and participated in a crew qualification live-fire exercise with their unit. Bridgers et al. concluded that the simulator training produced no significant change in gunnery skills but that it maintained or enhanced proficiency on some of the contact flight skills.

However, the results of the second experiment are severely confounded: no control group was used, testing and training was conducted over a very short period of time, and the authors acknowledged that the gunnery performance measures were insensitive. As a result, the data from this experiment cannot support any conclusions about the effectiveness of the FWS for sustaining operational flight or gunnery skills. Both of the experiments reported by Bridgers et al. (1980) demonstrate the need for additional research on the effectiveness of the FWS, especially for unit training and for gunnery training.

Using the data collected during operational testing (i.e., Bridgers et al., 1980), Hopkins (1979) conducted a cost and training effectiveness analysis of the FWS. He concluded that (a) the FWS provides the opportunity for aviators to fire as many rounds as necessary to maintain their gunnery proficiency, (b) all individual and crew gunnery training can be accomplished, (c) the instrument flight characteristics of the FWS are outstanding, and (d) the FWS is excellent for practicing emergency procedures. Despite the questionable utility of the operational test data, Hopkins recommended that aviation units conduct gunnery, instrument, and basic flight training in the FWS. Hopkins used the Army's annual expenditures of ammunition and training flight time to calculate cost savings and to justify the purchase and fielding of the FWS.

Finally, Luckey, Bickley, Maxwell, and Cirone (1982) conducted operational tests of the UH60FS for institutional training. Complete data were collected for 151 UH-60A transition students over a 6-month period. Some of the students received normal aircraft training, some received only UH60FS training, and some received training that alternated between the simulator and the aircraft. Two types of visual systems were tested: one simulator had a camera model system and the other simulator used a digital image generation system.

Luckey et al. (1982) drew four general conclusions from the operational test of the UH60FS. First, they concluded there was positive training transfer from the simulator to the aircraft for some aviator tasks. Second, they concluded that pretraining in the simulator was more effective than alternating training between the simulator and aircraft. Third, they found no significant overall differences between the two simulator visual systems. Fourth, they noted serious safety and reliability deficiencies in the UH60FS.

Only limited data and information about the analytic procedures used are presented in the Luckey et al. (1982)

report, so it is difficult to determine whether their conclusions are valid. Whether valid or not, the research was clearly limited to transition training in the institution. It did not address the issues related to the primary utilization of Army simulators: training and sustaining the skills of operational unit aviators.

Flight Simulation Plan Audits

The U.S. Army Audit Agency (AAA) criticized the Army's simulator acquisition and distribution plans on two occasions. The central issue in both audits was the lack of empirical data to support the fielding of flight simulators for use by aviation units; the use of flight simulators for institutional training was not criticized.

In 1981, the AAA audited the Army plan and concluded there were insufficient data to justify the number of flight simulators scheduled for purchase or the distribution of simulators to aviation units (U.S. Army Audit Agency, 1982). The AAA found insufficient empirical evidence that flight simulators can meet the aviation unit training requirements. In addition, they found insufficient data to guide the development of flight simulator training programs so that unit aviators can derive the optimum benefit from the training devices.

In the 1982 report, the AAA recommended that the Army initiate a program of research to compile the data needed to address these issues. In 1984, the AAA conducted a follow-up audit of the Army's flight simulation program, with similar results. The AAA criticized the Army for failing to obtain the research data needed to justify the planned acquisition and deployment of the flight simulators to operational units (U.S. Army Audit Agency, 1985).

Postfielding Simulator Research

In response to the AAA criticisms of the Army flight **simulation program, the U.S. Army Research Institute Field Unit at Fort Rucker, Alabama, developed a plan** for simulator research (Cross & Gainer, 1987). The research plan is divided into long-term and short-term paths. The long-term path addresses basic research issues related to the design of future flight simulators. The short-term path addresses issues related to the evaluation and optimal use of the flight simulators being purchased and fielded by the Army. The short-term path emphasizes the need to investigate small groups of tasks within the context of aviation unit training requirements.

Three experiments have been conducted by the Fort Rucker Field Unit within the short-term path. All the experiments were conducted in the FWS, primarily because it was the first simulator to be fielded for aviation unit training.

Backward transfer. In the first experiment, Kaempf, Cross, and Blackwell (1989) used a backward transfer paradigm to investigate the level of FWS fidelity and to predict the effectiveness of the FWS for training emergency maneuvers. In the backward transfer paradigm, aircraft-proficient but simulator-naive aviators are required to perform flight tasks in the simulator. If the aviators cannot perform the tasks satisfactorily, the simulator is assumed to have deficiencies that limit its utility as a training device. If the aviators can perform the tasks satisfactorily, simulator training probably, although not necessarily, will transfer to the aircraft. The advantage of performing a backward transfer experiment as the first step in a research program is that it can be conducted more quickly and less expensively than a forward transfer experiment.

Sixteen AH-1 instructor pilots (IPs) assigned to the AH-1 AQC were administered a checkride in the AH-1 followed by an identical checkride in the FWS. On both checkrides, the aviators performed one iteration of each of eight emergency maneuvers. Standardization IPs (SIPs) graded the aviator's performance on each trial. Most (82%) of the iterations were graded as satisfactory in the aircraft; the same percentage of iterations was graded as unsatisfactory in the FWS.

The IPs attributed their poor FWS performance to deficiencies in the simulator's visual system and to the handling and response characteristics of the flight controls. Kaempf et al. (1989) concluded that the FWS has some fidelity deficiencies that degraded the experienced AH-1 aviators' capabilities to perform emergency maneuvers to touchdown in the FWS. The authors predicted that forward transfer of training from the FWS to the AH-1 would be low for emergency touchdown maneuvers (ETMs).

Skill acquisition. The results of the backward transfer experiment raised several issues that were investigated in the subsequent skill acquisition experiment, also reported in Kaempf et al. (1989). The primary objectives of the second experiment were to determine (a) the rate at which operational aviators acquire skills in the FWS and (b) the level of proficiency that aviators can attain in the FWS.

In the skill acquisition experiment, three groups of 10 operational aviators each performed 10 iterations of 5 different maneuvers in the FWS pilot station. The 15 maneuvers included the 8 ETMs examined in the backward transfer experiment and 7 standard contact maneuvers. A fourth group of 10 aviators practiced a subset (n = 5) of the 15 maneuvers in the copilot/gunner (CPG) station. Two SIPs evaluated the aviator's performance on each iteration.

The operational aviators demonstrated significant improvement in performance across the training trials on all the maneuvers except for four ETMs. Regression equations derived from the data predicted that operational aviators will require significant amounts of training in the FWS to reach a satisfactory level of proficiency on all the maneuvers evaluated. The average number of repetitions predicted for aviators to reach a satisfactory level of proficiency in the FWS ranged from 9 repetitions for Manual Throttle Operation in the pilot station to 28 repetitions for Hovering tasks in the CPG station.

In summarizing the results of both experiments, Kaempf et al. (1989) concluded that significant differences exist between the FWS and the AH-1 aircraft and that the two should not be considered as interchangeable training devices. They also concluded that forward transfer-of-training experiments are needed to determine the relationship between training conducted in the flight simulator and subsequent aviator performance in the helicopter.

Emergency touchdown maneuvers. The previous research (Bridgers et al., 1980; Kaempf et al., 1989) raised concerns about the effectiveness of the FWS for training ETMs. ETM training is a critical issue for the Army because many ETMs are considered too dangerous to practice in the aircraft outside the institutional environment. Since 1983, the Army has prohibited unit aviators from practicing eight ETMs (dual hydraulics failure, left and right antitorque failure, and five types of autorotation) because losses from training accidents were greater than losses from actual aircraft failures. In 1986, Farnham and Rowe estimated the ETM proficiency of operational aviators by observing their performance when assigned to the USAAVNC IP course. They concluded that the majority of the operational aviators lacked the skills needed to perform the prohibited maneuvers successfully.

Kaempf and Blackwell (1990) obtained a waiver of the ETM prohibition and evaluated the ETM proficiency level of operational aviators and the effectiveness of the FWS for training five of the ETMs. Twenty operational unit aviators were divided into control and experimental groups that were equated for prior experience and ETM performance during pretest checkrides in the AH-1 and in the FWS. The 10 control group aviators were trained to proficiency on the five ETMs in the aircraft. The 10 experimental group aviators were trained to proficiency first in the FWS and then in the aircraft.

Kaempf and Blackwell (1990) drew four general conclusions from the results of this experiment. First, operational aviators are not proficient on any of the five ETMs evaluated. The performance level of the aviators on the pretest checkride, in combination with the results reported by Farnham and Rowe (1986), indicate that most operational aviators could not safely terminate an emergency maneuver on the ground during an actual emergency. Second, operational aviators require relatively little training in the aircraft to regain proficiency on each of the five ETMs. The control group aviators required an average of 5.6 trials to regain proficiency on each maneuver.

Third, the FWS is moderately effective for training operational aviators to perform the five ETMs. The experimental group aviators required significantly fewer trials in the aircraft to regain proficiency on each maneuver (an average of 3.0 trials) and required significantly fewer aircraft training hours (3.4 versus 6.7 hours per aviator) than the control group aviators. Fourth, training to proficiency in the FWS alone does not prepare an aviator to deal safely with an in-flight emergency. Although FWS training did enhance ETM performance and the efficiency of subsequent training in the aircraft, most of the experimental group aviators did not perform the ETMs satisfactorily during their first exposure to the aircraft following simulator training.

Kaempf and Blackwell (1990) recommended three actions on the basis of their results. First, they recommended that operational units require their aviators to conduct periodic ETM training in the FWS. Second, they recommended that the Army either reexamine the policy prohibiting ETM practice in the aircraft or initiate a product improvement program for the FWS so that operational aviators can sustain their ETM proficiency in the simulator. Third, they recommended that additional transfer-of-training research be conducted to investigate the rate and amount of skill decay that occurs over an extended period of time and the effectiveness of the

FWS for sustaining operational aviators' skills in performing other flight and mission tasks.

FWS Effectiveness for Sustaining Gunnery Skills

The previous helicopter simulation research has focused on the acquisition or reacquisition of individual skills over short time periods. The next experiment in the short-term path was designed primarily to examine the training effectiveness of the FWS for sustaining operational unit crew skills over an extended period of time. Specifically, the experiment focused on the sustainment of AH-1 gunnery skills in the FWS.

The high cost of ammunition and the lack of adequate live-fire ranges make it difficult for Army attack aviators to develop and maintain their gunnery skills in the aircraft. A recent survey found that the FWS was being used to a moderate degree to augment AH-1 live-fire training. However, the attack aviators and unit commanders who responded to the survey rated the FWS as having only low to moderate training value for all gunnery tasks except weapon system switchology and weapon emergency procedures training (McAnulty, Cross, & DeRoush, 1989; McAnulty & DeRoush, 1988).

In addition to questions about the effectiveness of the FWS for gunnery skill sustainment training, the Army Standards in Training Commission (STRAC) and the USAAVNC **requested that the Fort Rucker Field Unit collect empirical information about the ammunition requirements and standards for crew qualification. Therefore, the current research was designed to meet the following four objectives:**

- determine whether the FWS is effective in sustaining AH-1 crew gunnery skills,
- compare the effectiveness of different amounts of FWS training for sustaining gunnery skills,
- estimate the ammunition requirements for crew gunnery qualification, and
- evaluate the standards for crew gunnery qualification.

Method

This experiment employed a forward transfer-of-training paradigm to address the research objectives identified in the previous section. Figure 1 depicts the principal steps in the design. Operational crews assigned to units of the U.S. Army, Europe (USAREUR) were evaluated on their military and

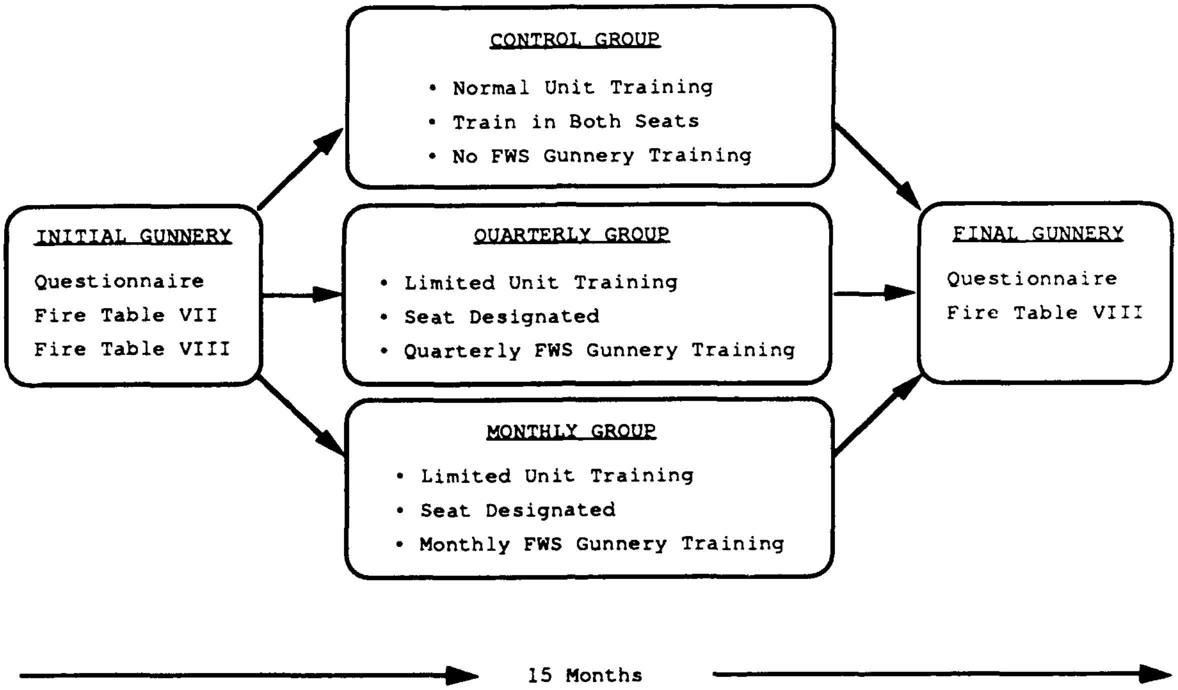

Figure 1. An overview of the FWS training effectiveness analysis research design.

flight experience, knowledge of the AH-1 weapon systems, and gunnery proficiency during an initial live-fire exercise. The crews were then assigned to either the control group, the quarterly FWS training group, or the monthly FWS training group.

The control group crews continued with their normal unit training in the aircraft but were restricted from gunnery practice in the FWS. The experimental group crews received supervised gunnery training in the FWS but were restricted on their gunnery training in the aircraft; there were no restrictions on their aircraft training other than gunnery. The crews' gunnery performance was assessed again during a final live-fire exercise conducted approximately 15 months after the initial exercise.

Apparatus and Materials

Two types of flight systems were used in this experiment: the AH-1 aircraft and the AH-1 FWS. The two flight systems are described in the first two parts of this section. The last four parts of this section describe the data forms used to collect knowledge, background, and unit training information about the aviators; the training scenarios that were developed for the FWS training; the crew gunnery tables used in the live-fire exercises; and the standards for scoring the exercises.

AH-1 aircraft. Fully modernized versions of the AH-1 aircraft, designated the AH-1F, were used during the live-fire exercises and during normal unit training for the aviators participating in this experiment. The AH-1F is a single engine, two-bladed helicopter with tandem pilot (back) and CPG (front) stations (see Figure 2).

The AH-1F is equipped with three weapon systems. The 20 mm gun is located under the nose of the helicopter and can be fired in either the fixed or flex modes. It can be aimed by using the telescopic sight unit (TSU) in the CPG station, the gunner's helmet sight (GHS), or the pilot's helmet sight (PHS). The capacity of the ammunition box is 750 rounds, which are fired in bursts of 16 (± 4) rounds when the cyclic trigger switch is pressed to the first detent.

The 2.75 in. rockets are carried in tube launchers (not shown in Figure 2) located on the wing store racks and can be fired in the direct, indirect, diving, or running fire modes. Each tube launcher holds 7 to 19 rockets. The rockets are normally fired by the pilot in pairs, one from each side of the aircraft, but the CPG usually assists in determining the

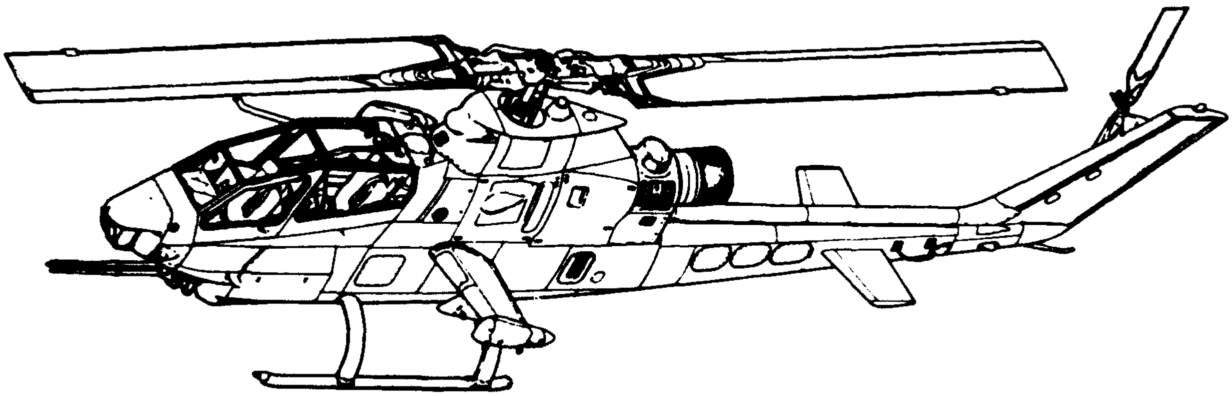

Figure 2. Diagram of the AH-1F helicopter.

range and sighting the target. The pilot can select the type of warhead (e.g., high explosive, illumination), fuze, quantity, and rate of firing for each engagement.

The main weapon system on the AH-1F is the tube-launched, optically-sighted, wire-guided (TOW) missile. The TOW missiles (not shown in Figure 2) are also carried on the wing store racks; a maximum of 16 TOWs can be carried by the AH-1F if the aircraft is not armed with rockets. The TOW missile is aimed, fired, and guided to the target by the CPG, but the pilot must maintain the aircraft within flight constraints from target acquisition until missile impact. TOW missiles must be fired one at a time.

AH-1 FWS. The production model of the FWS comprises a pilot cockpit and a CPG cockpit (see Figures 3 and 4), each mounted on a separate six-degree-of-freedom motion platform. The pilot and CPG stations within the cockpits are identical to the AH-1F aircraft stations. The two cockpits can be operated in an integrated mode or an independent mode; the integrated mode was used for all FWS training during this experiment. An instructor/operator (I/O) station is located directly behind the crew station in both cockpits. Each cockpit also has a jump seat located behind the I/O station that can be used to observe I/O activities and crewmember performance.

Visual scenes are displayed on two channels (front and left windows) in the pilot station and on a single channel (front window) in the CPG station when the cockpits are operating in the integrated mode. The visual scenes are produced by a Laser Image Generation (LIG) system traversing a three-dimensional terrain modelboard that replicates a generic gaming area of approximately 7.3 x 19.5 km. The LIG system employs a multicolored laser beam that scans the highly detailed modelboard. Scattered and reflected light is picked up by a bank of photomultiplier tubes. The outputs from all the photomultiplier tubes are added to produce a composite video signal as the gantry duplicates the flight path of the simulated aircraft.

Target and weapon effects are simulated in the FWS by computer-generated imagery. For 20 mm and rocket engagements, an aiming dot is generated that serves as the target. The aiming dot target is in a fixed geographic position but can be engaged from any location that is within range and affords intervisibility with the target. To employ the TOW missiles, the FWS must be maneuvered into specific target engagement points (TEPs) and the pilot must hold the aircraft altitude and heading within narrow constraints.

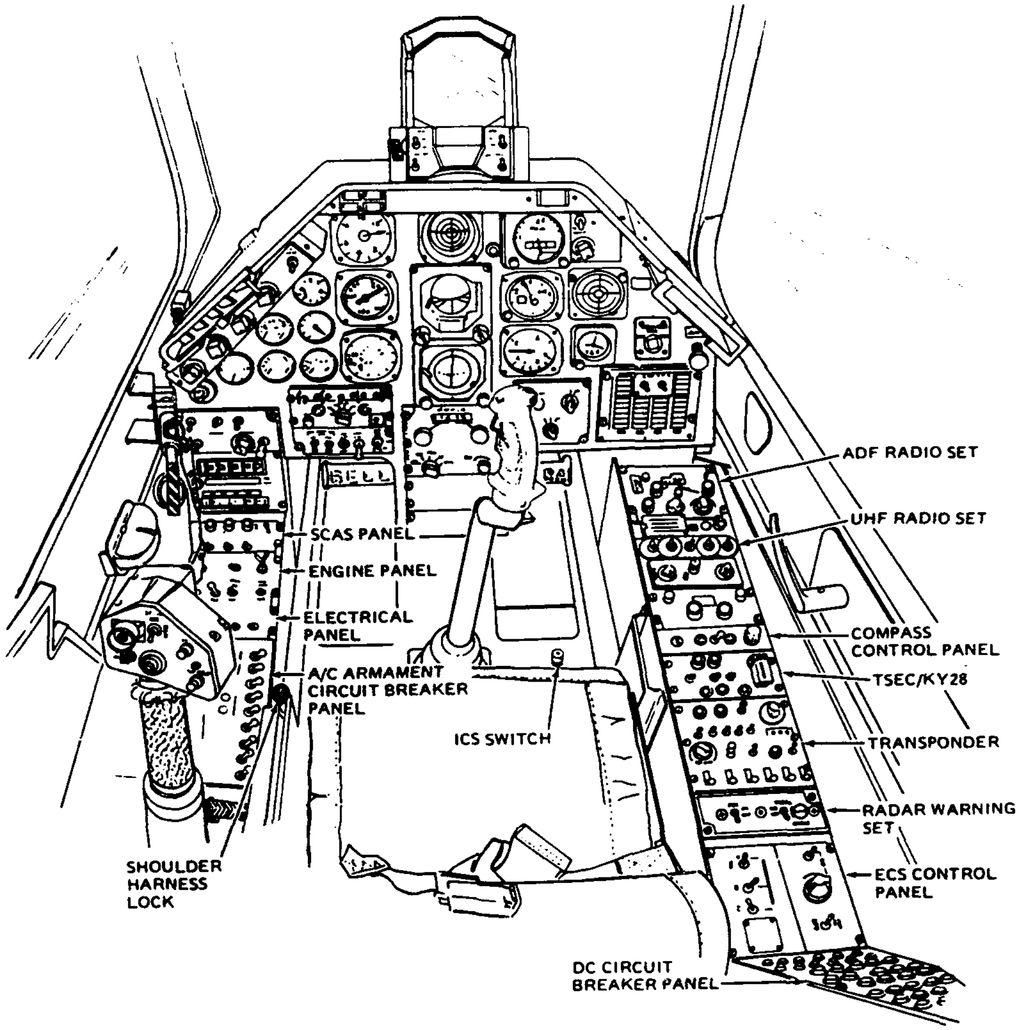

Figure 3. Diagram of the pilot station.

When in constraints, computer regenerated images from scene photographs (CRISP) targets are presented to the CPG in the TSU. The CRISP targets can be fixed or moving and can return fire at the simulated aircraft. Visual, aural, and kinesthetic weapon effects are generated when a weapon system is fired.

FWS scenarios. Eight tactical scenarios and one firing range scenario were developed and used during the FWS training sessions. Appendix D contains the situation sheet and the I/O target handover sheet for each scenario. The primary difference between the types of scenarios was that enemy threats were only included in the tactical scenarios,

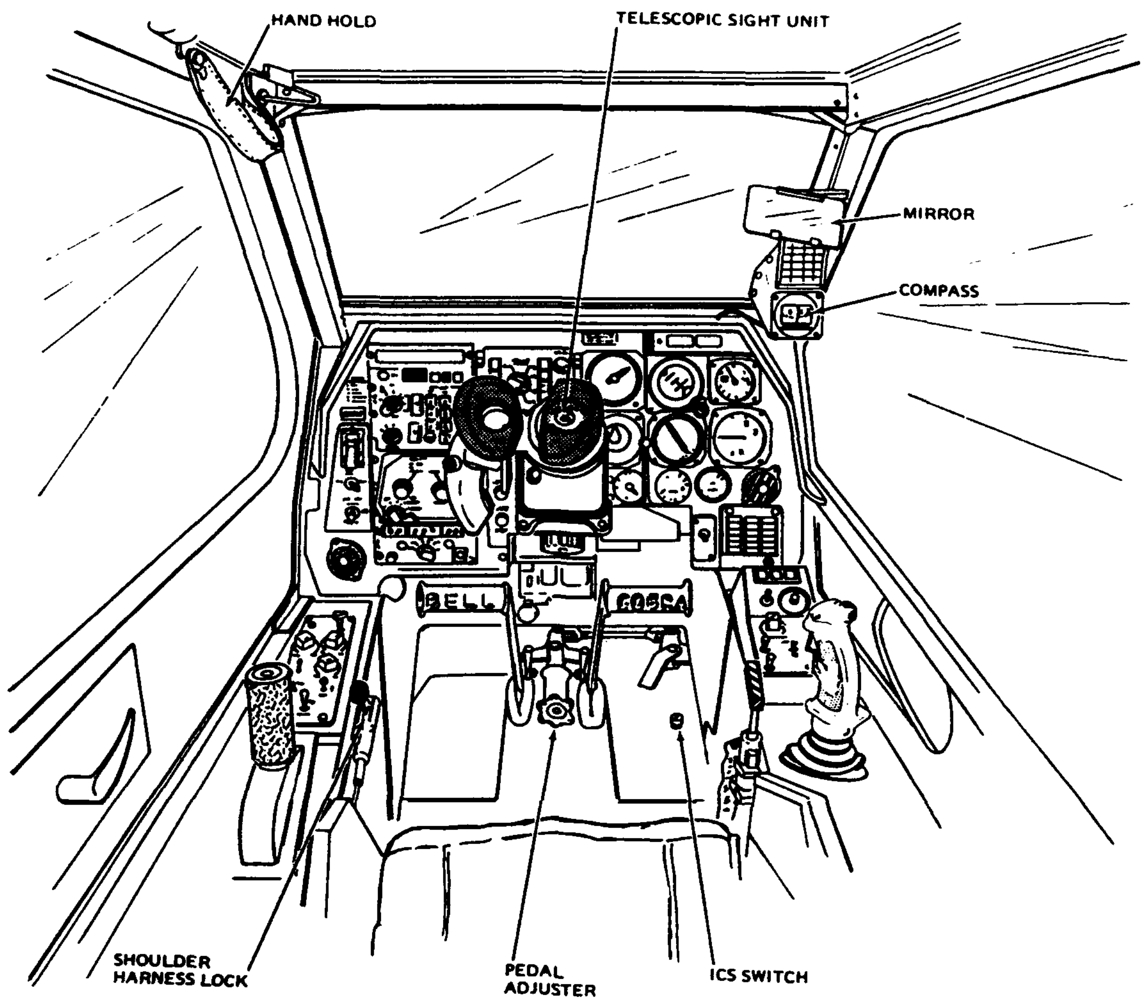

Figure 4. Diagram of the copilot/gunner station.

which forced the crew to maintain a low-level flight profile and to evade enemy radar while traveling between firing points. Although not shown on the scenario situation sheets, each aircrew was subjected to inadvertent instrument meteorological conditions and equipment failures during the return to base at the end of each training session.

Four of the tactical scenarios and the range scenario were day deployments; the other four tactical scenarios were dusk deployments. The ceiling (900 feet overcast), visibility (6000 m with haze), temperature (11 degrees Centigrade), and altimeter setting (28.55) were constant for all missions. Wind velocity and direction varied across scenarios. In addition to the situation sheet, the crew was given communications frequencies, performance planning cards, and maps to use in planning and conducting the simulated attack helicopter mission.

All three weapon systems (gun, rocket, and missile) were exercised at least once during each scenario, although not always in all modes. The order in which the weapon systems were employed and the distances and headings to the targets varied across the tactical scenarios. In the simulator firing range scenario, the order of weapon engagements was identical to the engagements required on the crew qualification table used during the live-fire exercises; the distances to the targets approximated the distances used during the live-fire exercise.

<u>Data forms</u>. Three types of data forms were developed and used to collect information from the participating aviators. First, all the aviators took a diagnostic gunnery skills test (see Appendix A) about the AH-1 flight and weapon systems before beginning the initial live-fire exercise. The primary purpose of the test was to ensure the aviators had recently reviewed the AH-1 training and operating manuals. The test results were not used to assign aviators to training groups because they all obtained high scores on the test.

Second, the aviators completed an AH-1 Aviator Questionnaire (see Appendix B) before both the initial and final live-fire exercises. The initial questionnaire administration was designed to collect personal, flight, and gunnery background data about the aviator that could be used to equate the experience levels of the training groups. The same questionnaire was administered at the end of the project to verify the original data and to estimate aviator flight and gunnery experience during the project.

Finally, the aviators were instructed to complete a Postflight Debriefing form (see Appendix C) after each flight in the AH-1 and after each FWS training session. The purpose of this form was to collect information about aviator aircraft training during the project and aviator simulator training that was not part of the FWS training effectiveness analysis (TEA) project (e.g., instrument flight or emergency procedures training; gunnery practice in the nonassigned crew station).

<u>Gunnery range</u>. The live-fire exercises were conducted on Range 301 at the Grafenwoehr Training Area in the Federal Republic of Germany. Range 301 is approximately 5000 m long and 2000 m wide. Aircraft enter at the western end of the

range and proceed downrange toward the east. There are trees and berms on the western half of the range that were used to mask the aircraft before and after firing. Throughout the eastern half of the range, there are pop-up targets that were used for 20 mm engagements. In the southwestern corner of the range, there is a 300 m (horizontal) by 600 m (vertical) impact area that was used for rocket engagements. Just north of the rocket impact area is a target that moves along a north-south track that was used for the TOW engagements.

There are two observation towers located on the western edge of the range. The low tower was used for range control (command post, range safety, air traffic control, and activation of targets) and the high tower was used for scoring. The high tower enabled an unobstructed view of the entire range and contained a high power field telescope. An intercom system was available for communication between the two towers. Personnel in both towers could communicate by radio with the airborne range controller (the unit SIP) and could monitor the radio communications of the scout and attack helicopters.

Crew gunnery tables. During the initial live-fire exercise, the participating crews fired the USAREUR versions of Table VII (crew training table) and Table VIII (crew qualification table) adapted from the U.S. Army helicopter gunnery manual (FM 1-140; Department of the Army, 1986). During the final live-fire exercise, the crews fired only Table VIII.

USAREUR Table VII consists of 10 engagements conducted from seven firing positions. The 20 mm gun and the 2.75 in. rocket system were each fired in five engagements; the TOW missile system was not fired during the practice table. Engagements 1 and 7 were single engagements using the 2.75 in. rockets; engagement 1 was fired in the indirect mode from approximately 3600 m and engagement 7 was fired in the direct mode from approximately 3000 m. Engagements 2 and 8 were single engagements using the 20 mm gun; engagement 2 was fired from approximately 700 m using the PHS and engagement 8 was fired from approximately 1100 m using the TSU.

The remaining engagements employed the 20 mm gun and the 2.75 in. rocket system in combination. The rockets were always fired in the direct mode on the combined engagements at ranges of approximately 2300 m to 3000 m. The 20 mm gun was sighted on the first two combined engagements with the TSU; on the last combined engagement, the 20 mm gun was sighted using the PHS. The 20 mm combined engagements were fired at ranges of approximately 500 m to 1200 m.

The performance of the participating crews on USAREUR Table VIII during the final live-fire exercise was the primary criterion measure of FWS training effectiveness. Table VIII also consists of 10 engagements conducted from seven firing positions (see Table 1). Engagements 3 and 4, 5 and 6, and 7 and 8 employed the 20 mm gun and 2.75 in. rocket systems in combination. The 20 mm gun was used for five engagements and the 2.75 in. rockets were used for four engagements. The final engagement was a TOW missile shot. The weapon systems were exercised in all possible modes from a hover. The distances from the firing positions to the targets ranged from approximately 300 m (engagement 4) to 3600 m (engagement 1).

Scoring standards. The scoring standards developed and used by aviation units in the 3rd Infantry Division were adopted for scoring the live-fire exercises. Each engagement could receive a maximum score of 100 points. The engagements were scored according to three weighted criteria: engagement time received 15% of the weight, exposure time received 25% of the weight, and target effect received 60% of the weight.

Table 1

The USAREUR Crew Qualification Table (Table VIII)

Pos	Eng	Weapon	Mode	Rounds	Range (m)
1	1	Rockets	Indirect	4	3600
2	2	20 mm gun	CPG TSU	32	1000
3	3	Rockets	Direct	4	2900
	4	20 mm gun	CPG HS	32	300
4	5	Rockets	Direct	4	2300
	6	20 mm gun	CPG TSU	32	650
5	7	Rockets	Direct	4	2100
	8	20 mm gun	CPG TSU	32	1000
6	9	20 mm gun	Pilot HS	32	500
7	10	Missile	Direct	1	2450

Note. USAREUR = U.S. Army, Europe; Pos = firing position; Eng = engagement; CPG = copilot/gunner; TSU = telescopic sight unit; HS = helmet sight.

Engagement time is the time from target handover until the engagement is completed. Exposure time is that part of engagement time in which the AH-1 aircraft is unmasked and has intervisibility with the target. Target effect is whether or not the rounds hit the target or are close enough to suppress the target.

Minimum standards of successful performance (go engagements) were established for each criterion for each engagement. The standards for the engagement and exposure time criteria were a function of the weapon system(s) used, the firing mode, and the distance to the targets (see Table 2). A combined engagement and exposure time were used for engagements 3 and 4, 5 and 6, and 7 and 8 because the 20 mm gun and the rockets were fired during each exposure.

The standards for target effect were solely a function of the weapon system used. Both the 20 mm gun and the rocket systems are designed to suppress enemy fire while the crew fires the main weapon system, the TOW missile. The only acceptable engagement for the TOW missile was a target hit because the primary mission of the AH-1 is to destroy enemy armor. Conversely, a target hit by the two area weapons is

Table 2

Standards for Table VIII

Engagement	Exposure time (seconds)	Engagement time (seconds)	Target effect
1	33	70	2 rockets in box
2	16	35	hit or 50% in box
3	33	105	2 rockets in box
4	"	"	hit or 50% in box
5	33	105	2 rockets in box
6	"	"	hit or 50% in box
7	33	105	2 rockets in box
8	"	"	hit or 50% in box
9	10	30	hit or 50% in box
10	25	45	hit on moving target

not necessary for an engagement to be successful. The criteria for success is that 50% of the 20 mm or rocket rounds must hit within a defined but unmarked box around the target. For the 20 mm gun, the crew must hit the target or get 50% of the rounds within a 50 m x 50 m box around the target. For the rockets, the crew must hit a 300 m (horizontal) x 600 m (vertical) rocket box with at least two of the four rockets available for each engagement.

In addition to a dichotomous decision of go or no go (successful or unsuccessful engagement), points were awarded for each component of each standard. That is, higher scores could be obtained by exceeding the minimum standards (see Table 3 for examples of the score ranges). The target effect score for rockets could be increased above the minimum go score (42) in two ways. As shown in Table 3, higher scores could be obtained by hitting the rocket box with more than two of the four rockets allowed for each engagement. To conserve costly ammunition, however, maximum scores were also awarded if the first pair of rockets hit the box (i.e., 100% accuracy for the first two rockets). Table 3 also shows that points were awarded for performance that was close to but

Table 3

Representative Scoring Values for Tables VII and VIII

Engagement time (105 second std.)		Exposure time (33 second std.)		Target effect (rocket std.)	
Seconds	Points	Seconds	Points	Box hits	Points
0 - 53	15	0 - 18	25	4	60
54 - 65	14	19 - 21	24	3	51
66 - 80	13	22 - 23	23	2	42
81 - 95	12	24 - 25	22	1	21
96 - 105	11	26 - 27	21		
106 - 115	4	28 - 29	20		
116 - 125	2	30 - 32	19		
		33	18		
		34 - 37	6		
		38 - 40	2		

Note. std. = standard.

below the minimum standard. To qualify on Table VIII, the crew had to obtain a minimum of 700 points and seven go engagements.

Personnel

Three types of personnel participated in this research: AH-1 aviators, FWS I/Os, and range scoring personnel. Because aviators attrited and the IPs and scorers changed during the course of the project, the description of the personnel concentrates on the personnel who participated during and immediately preceding the final live-fire exercise.

Aviators. During the initial live-fire exercise, 50 aviators (25 crews) from the two USAREUR Corps were selected to participate in the FWS training effectiveness research. The crews were then assigned to training groups on the basis of their flight experience and gunnery performance during the initial live-fire exercise. Twenty aviators were assigned to each experimental training group. Because each aviator was assigned to either the pilot or CPG station, there were 10 crews in each of the quarterly and monthly training groups. The 10 aviators in the control group were allowed to train and to qualify in both stations, so there were also 10 crews assigned to the normal unit training group.

During the course of the research project, 60% of the originally selected crews were unable to complete the scheduled gunnery training and final crew qualification exercise. There were three primary reasons for the loss of crews. First, one of the participating units withdrew its support for the project because of conflicts with its operational mission. Second, other crews in the same Corps began but were unable to complete the final live-fire exercise because of a weather-induced lack of range time and a shortage of rockets. The rocket shortage occurred because the delivered ammunition was double stenciled and the actual rocket type could not be identified before the range time expired. For operational reasons, these crews could not continue their FWS training and return to the range at a later time.

Finally, individual aviators were unable to complete the research requirements because of early transfer, medical grounding, loss of pilot-in-command status, and scheduled transfer during an involuntary 3-month extension of the project. The project was extended because the scheduled range time for the final live-fire exercise was preempted by an incoming division commander for a combined arms training exercise. Because crew gunnery performance was the unit of measurement, the loss of an individual aviator resulted in the loss of an entire crew.

Although a majority of the original crews was unable to complete the project requirements, the losses occurred equally across the three training groups. When the data collection was completed, four crews remained in each group. In general, the initial demographic data on the retained aviators are very similar for each group (see Table 4). The largest differences are in the ranks of the aviators and in the percentage of aviators that had previously qualified on crew gunnery. The majority of aviators in the quarterly training group held the rank of WO1 and only the monthly training group had any aviators above the rank of CW2. All

Table 4

Aviator Demographic Data at the Initial Live-Fire Exercise

Measure	Control (n = 4)	Quarterly[a] (n = 8)	Monthly (n = 8)
Age (years)	25.0	26.0	25.5
Rank (%)			
WO1	50.0	62.5	37.5
CW2	50.0	37.5	25.0
CW3/4			25.0
1LT			12.5
Months Since AQC	18.5	20.0	20.0
Months in Unit	11.0	11.0	11.0
First Assignment (%)	75.0	75.0	62.5
Readiness Level 1 (%)	100.0	100.0	100.0
Crew Qualified (%)	100.0	57.1	100.0
Skill Self-Rating	5	5	6

Note. The data are either percentages of aviators (%) or medians. AQC = AH-1 Aviator Qualification Course.

[a]Only 7 aviators responded to the question about prior crew qualification.

the aviators in the control and monthly training groups but only 57.1% of the quarterly training group had previously qualified on crew gunnery before the initial live-fire exercise.

The skill self-rating shown in Table 4 is the median rating each aviator assigned himself on nine gunnery tasks (see Appendix B, item 38). The rating scale ranged from 1 (well below average pilot) to 9 (well above average pilot); a rating of 5 was defined as the average pilot. Most of the aviators considered themselves to be near the average on most of the gunnery tasks. The slightly higher median rating for the monthly training group probably reflects the higher ranks (and associated experience) of these aviators. The initial gunnery performance of the crews in each group will be presented in the Results section.

The aviators retained in each group were also very similar in their self-reported flight experience prior to the initial live-fire exercise (see Table 5). The differences in flight hours are much larger within each group than among the groups. The extreme range in the monthly training group for other aircraft hours is attributable to the CW4 who was

Table 5

Median (and Range) of Aviator Flight Hours at the Initial Live-Fire Exercise

Measure	Control (*n* = 4)		Quarterly (*n* = 8)		Monthly (*n* = 8)	
Career Hours						
AH-1	400	(505)	385	(880)	338	(1140)
Other Aircraft	190	(385)	200	(145)	225	(6245)
FWS	29.0	(32)	32.5	(185)	42.5	(52)
Hours Last 6 Months						
Pilot	40.0	(80)	42.5	(75)	50.0	(62)
CPG	32.5	(55)	30.0	(85)	32.5	(65)
FWS	10.0	(10)	8.0	(9)	11.0	(13)

Note. FWS = Flight and Weapons Simulator; CPG = copilot/gunner.

assigned to that group. Because he was assigned as a CPG in this project, his extremely high level of flight experience in unarmed aircraft probably did not significantly affect his gunnery performance. The recent experience levels of the aviators in the AH-1 and FWS are probably better indicators of initial group equivalence. Both the medians and ranges for pilot, CPG, and FWS hours during the last 6 months are similar across the three groups. All the aviators had sufficient prior experience in the FWS to assume they would not require simulator-specific training (cf. Kaempf et al., 1989).

Additional information about the aviators' gunnery experience was requested at the initial and final live-fire exercises, but the data are not reliable. Specifically, some of the aviators estimated they had fired more ammunition before the project began than after it was completed. Unlike flight hour records that are mandated by regulation, Army aviators are not required to maintain records of ammunition expended. Therefore, the self-reported previous gunnery experience data were not included in evaluating the initial equivalence of the three training groups.

FWS instructors. Six senior Aviation Warrant Officers served as I/Os during the FWS training for the retained crews. During each training session, the I/O also played the roles of air traffic control, forward arming and refueling point (FARP) radio, and scout aircraft directing the AH-1 gunship. Three of the I/Os were IPs or SIPs for the participating units. Two of the I/Os were Flight Simulator Facility AH-1 IPs. Finally, a retired AH-1 IP served as the I/O when the unit or facility IPs were not available.

All the I/Os were highly experienced AH-1 aviators and instructors who were certified as FWS operators. The I/Os were thoroughly briefed on the purpose, design, and procedures of the research project. In fact, some of the I/Os participated in designing the scenarios and range exercises. In addition, the on-site researcher reviewed the training scenario with the I/O before each training session while the crew planned the flight.

Scoring personnel. Different personnel were involved in scoring each of the range exercises. Because it was the primary criterion measurement, the personnel who scored the final live-fire exercise for the retained crews are described in the following paragraphs to represent the general approach to scoring.

Except for the unit SIP, the scoring was performed by personnel stationed in the range high tower. As the airborne range controller, the unit SIP determined target effect for engagements that were not adequately observed by the tower personnel. The scoring was supervised and the weighted scores recorded by a First Lieutenant who observed the exercise through the high power field telescope. The unit IP maintained radio communications with the range operators and airborne controller; he was also responsible for determining when the aircraft had unmasked and remasked.

Two enlisted men used field binoculars to evaluate the target effect for each engagement; on combined engagements, one soldier scored the rocket effect and the other scored the 20 mm effect. A third soldier used a bank of eight stopwatches to measure the engagement and exposure times. Finally, a Sergeant collected and converted the raw component scores into a weighted total score for each engagement.

All the scorers were well trained and proficient in performing their assigned tasks. The most difficult task was scoring the effect of the area weapon systems, especially the 20 mm gun. Despite the difficulty in scoring these two systems, there was very little controversy over the appropriate score for any engagement. The unit IP, the Sergeant, and two researchers also observed the target effect through field binoculars, but never had to intercede because of an inappropriate scoring decision.

Procedures

The overall procedure used in this research was described as an introduction to the Method section. In addition, other procedures were discussed in describing the flight systems, materials, or personnel that were used in this experiment. For example, the procedures used to score the range exercises were discussed in describing the scoring criteria and personnel. Three specific procedures are discussed in this section: training procedures for the control group, training procedures for the experimental groups, and range exercise procedures for all the participating crews.

Control group training procedures. Following the initial live-fire exercise, the control group aviators were instructed to continue their normal unit training and mission activities, with the following two exceptions. First, they were not allowed to conduct any gunnery practice in the FWS. Second, they were told to complete a Postflight Debriefing form after every flight in the AH-1 or FWS and to submit them periodically to the on-site researcher through the unit IP. Research personnel monitored the status (e.g., unit or station transfer problems) of the control group aviators, but had no direct contact with them between the initial and final live-fire exercises.

Experimental group training procedures. Following the initial live-fire exercise, the experimental group aviators were instructed to continue their normal unit training and mission activities, with the following three exceptions. First, they were not allowed to conduct any gunnery practice in the AH-1 aircraft while flying in their designated crew station (their crew station during the initial live-fire exercise). Second, they were told to complete a Postflight Debriefing form after every flight in the AH-1 or FWS and to submit them periodically to the on-site researcher through the unit IP or during FWS training sessions. Third, they were instructed to perform gunnery training as a crew in the FWS according to the schedule for their training group.

The on-site researcher coordinated FWS training sessions for each crew through the unit IP. Because of difficulties in coordinating FWS access (block use by other units or allied personnel, holiday and preventative maintenance down time) and the availability of the aviators and IPs (mission priorities, other duties, annual leave, etc.), the training could not be scheduled on an exact monthly or quarterly basis. FWS system failures, weather constraints (some aviators were stationed about 100 km from the simulator facility), and last minute changes to schedules further exacerbated the scheduling problems.

Although the time between FWS training varied somewhat within the groups, all the monthly group crews except one received 15 FWS sessions and all the quarterly group crews received 6 FWS sessions. One monthly group crew could not be scheduled for session 11. The first three and last two training scenarios were the same for both groups (see Table 6). The last session (the range scenario) for all FWS crews, which simulated the gunnery exercise, was conducted within 3 weeks of the final live-fire exercise.

The general procedure for FWS training was the same for both groups; only the frequency of training differed. When the crew arrived at the simulator facility, the researcher gave them a copy of the situation sheet, a tactical map, a contour chart, a weight and balance form, a communications frequency list, a performance planning card, and an instrument approach plate. The aviators were then given

Table 6

Order of AH-1 Flight and Weapons Simulator Scenarios for the Monthly and Quarterly Training Groups

Training session	Monthly training group scenario	Quarterly training group scenario
1	1	1
2	5	5
3	3	3
4	2	9
5	7	1
6	1	9
7	4	
8	6	
9	8	
10	9	
11	1	
12	6	
13	8	
14	1	
15	9	

Note. Scenarios 1 - 8 are tactical exercises; scenario 9 simulates the gunnery range. See Appendix D for a description of each scenario.

their crew station assignments (which alternated from one session to the next) and time to plan the mission. Mission planning time was usually 30 minutes to an hour, depending on the complexity of the mission.

While the crew was planning the mission, the researcher gave the I/O a copy of the scenario materials and reviewed the training procedures with him. They then set up the initial conditions for the scenario in the simulator. Finally, the I/O reviewed the mission plan with the crew.

Each FWS training session was conducted with as much realism as possible. The crew performed all their cockpit preflight functions (e.g., entering Doppler coordinates) and checks (e.g. hover power checks), obtained fuel and ammunition, and contacted air traffic control for clearance to depart. Once airborne, the crew maintained contact with their scout aircraft throughout the mission. The I/O played the roles of FARP radio, air traffic control, and scout, but only if the crew called on the appropriate radio frequency. The I/O reserved instructional comments until after the scenario was completed. The only exception to this approach was when there was a crash (e.g., a tree strike) or a system malfunction.

During the mission, the crew navigated through a threat environment to each battle position. The scout did not assist with navigation unless the crew called for assistance. The scout assisted the crew in maneuvering into the battle position (especially into the Target Engagement Points for TOW shots) and gave them the target handover. The crew set up the weapon system, unmasked, acquired and engaged the designated target, and remasked. The scout then called target effect or adjusted fire for the crew (i.e., called how many meters long, left, etc.). During each engagement, the I/O and researcher collected computer generated performance information (e.g., engagement time, ammunition expended, average miss distance, number of hits) and noted any problems the crew had in conducting the engagement.

When the target was destroyed or suppressed, the scout directed the crew to proceed to the next battle position or to return to base. If the crew expended all their ammunition or took too long en route, they had to return to base to rearm and refuel. During the transition between the battle positions, the crew was subjected to enemy threats and minor aircraft malfunctions. On the final return to base, the crew was exposed to either enemy fire, major system malfunctions, or instrument meteorological conditions, or some combination of these emergency situations.

When the scenario was completed, the IP and researcher debriefed the crew on their performance using the data collected and problems noted during the flight. If time permitted, the aviators changed crew stations and repeated the scenario or the parts of it that were most problematic. The additional training was at the discretion of the IP. Finally, the aviators completed the flight logs, returned the training materials, and submitted any Postflight Debriefing forms they had completed. The time required for each training sessions, excluding mission planning time and FWS malfunction time, ranged from 75 to 120 minutes.

Range exercise procedures. There were some differences in the procedures used during each of the live-fire exercises. For example, the crews fired both Tables VII and VIII during the initial range exercise but only fired Table VIII during the final exercise. The range procedures used during the final live-fire exercise for the retained crews are described in this section and are representative of the general range procedures used in all the exercises. Some aspects of the range procedures (e.g., scoring) have been described previously and are not repeated in this section.

On the evening before the range exercise began, the unit commander, operations officer, SIP, IP, and range control officer and the researcher briefed the participating aviators about the live-fire plan and range procedures. The final range exercise lasted for 3 days. Each AH-1 crew entered the range for their first qualification run loaded with 200 rounds of 20 mm ammunition, 16 rockets, and one TOW missile. The crew began the Table VIII qualification in firing position 1 and proceeded sequentially through firing position 7. The first run usually took 45 to 60 minutes to complete.

The AH-1 was accompanied down the range by two OH-58 helicopters. One OH-58 carried the airborne range controller, who ensured the attack crew knew the azimuth limits and had identified the range markers before allowing each engagement to proceed. The airborne controller also assisted in scoring target effect on some engagements and provided the range controller in the low tower with safety assessments during range fires and following missile malfunctions. The second OH-58 carried the scout, who gave target handovers to the gun crew and adjusted fire for them.

If the crew failed to qualify on the first run, they were required to repeat all no-go engagements in sequence, except for the TOW missile shot. If they failed either part of a combined engagement (e.g., received a go on the 20 mm but a no go on the rockets), they were required to repeat both parts. If the crew failed to attain seven go engagements between the first and second runs, they were required to rearm and fire the failed engagements again. All the crews were qualified within three runs down the range. Ammunition loads for the repeat runs were based on 40 rounds of 20 mm and 4 rockets for the respective engagements. The time for each repeat run varied as a function of the number of engagements fired.

Results and Discussion

The effectiveness of the FWS for sustaining gunnery skills was evaluated by comparing the live-fire performance of the three training groups during the initial and final range exercises. A mixed 2 x 3 factorial analysis of variance (ANOVA) design was used to determine if the main and interaction effects were statistically significant. The exercise (initial or final) factor was a within-subjects, or repeated measures, variable. The group (control, quarterly, or monthly) factor was a between-subjects variable. If the group or interaction effects in the ANOVA were significant, Newman-Keuls tests were used to determine which ANOVA cells were significantly different (Winer, 1971).

Effective transfer of training is best indicated by a significant interaction in which the groups are equivalent in performance during the initial exercise but show significantly different performance following the various training regimes. The Newman-Keuls analyses can then be used to determine if there are significant differences between only the control group and the experimental groups or between all three groups. Positive transfer is indicated when either or both of the experimental groups perform better than the control group during the final live-fire exercise; negative transfer is indicated if the control group outperforms the experimental groups.

Because of the aviator attrition during the 15 months of this experiment, the analyses were conducted with a very small number of subjects (i.e., crews) in each group. Two aspects of having a small sample must be considered in interpreting the statistical analyses. First, a single outlier in a small sample can drastically affect the group statistics. Except for the TOW missile points, however, a Cochran test of homogeneity of variance conducted before each ANOVA indicated there were no significant differences in variances for any of the performance measures.

Second, large differences in group averages or very small variances within groups are required to attain statistical significance when the degrees of freedom in the sample are small. Statistically significant effects obtained with a small sample in which the variances are relatively large are likely to be very powerful in the operational environment. However, when the members of each group show highly similar levels of performance (i.e., little or no variance), statistically significant effects may not be practically significant.

Conversely, some practically significant effects may not be statistically significant when tested with limited degrees of freedom. Although the analyses first test for statistical significance, consistent but nonsignificant trends are also examined in determining the effectiveness of the FWS for sustaining gunnery skills. Examining the consistency of results also helps to control for obtaining statistical significance by chance, which can occur when multiple measures of performance are evaluated.

The training effectiveness analyses were performed with four sets of aircrew performance measures. First, the total points scored and the number of go engagements on the first run down the range were analyzed to determine if there were any overall differences in crew gunnery performance. Second, the three components of the first run scores were analyzed separately to determine whether the training regimes significantly affected the speed or accuracy, or both, of the crews' gunnery performance. Third, the average points scored using each weapon system were analyzed to determine if the FWS training was more or less effective for each system. Fourth, the number of runs, the number of engagements, and the number of rockets required to qualify were analyzed to determine the effect of the training regimes on the resource requirements for gunnery qualification.

Estimates of the ammunition requirements for sustaining gunnery skills with the rocket system are drawn from the latter analysis. The cost of rockets is high enough that their use for live-fire practice is a major economic concern. In addition, a crew's performance firing pairs of rockets can be easily determined. The ammunition requirements for the other two systems were not estimated. Compared to the rockets, 20 mm ammunition is not expensive and the assessment of crew performance using the 20 mm gun is much more subjective. The TOW missile is prohibitively expensive to use in practice. Despite the lack of live-fire practice, AH-1 crews have historically been highly successful in using the TOW missile.

The final part of the Results section presents an analysis of the crews' performance on each engagement during the final live-fire exercise. The purpose of this analysis was to provide information about the standards for crew gunnery qualification.

First Run Overall Criteria

For the first attempt (run) at both Table VII (initial exercise) and Table VIII (initial and final exercises), each crew was scored on a point system that was a weighted average of their target effect, engagement time, and exposure time performance (see pp. 18 - 20). The crew also received a go or no go rating that was based on meeting the minimum criterion (e.g., see Table 2) on each of the three scoring factors. Regardless of their performance on the first run, the crews never repeated Table VII. If a crew scored less than 700 points or received less than seven go ratings on the first run on Table VIII, the crew repeated the failed engagements until they acquired the seven go ratings. Point scores were not awarded for repeat runs on Table VIII; if a crew required more than one run to qualify, the final point score was changed to the minimum of 700.

The first analyses were conducted to determine if there were significant differences in total points and number of go engagements between the training groups on the first runs in each live-fire exercise. During the initial exercise, Table VII performance represents the first run down the range for each crew during the exercise and Table VIII performance represents the first run on the crew qualification table. Because the crews did not fire Table VII during the final exercise, Table VIII represents both the first run down range and the first attempt at crew qualification on that exercise.

Total points. The mean total points scored on both tables during the initial live-fire exercise are near the minimum qualification score of 700 (see Table 7). The mean initial scores for Tables VII and VIII are almost identical for the control and monthly training groups, but there is a large increase in the mean score for the quarterly training group. The low mean score on Table VII and the subsequent improvement on Table VIII are probably a result of the prior gunnery qualification level in this group: nearly half the quarterly training group aviators were not crew qualified when the research began; all the other aviators were crew qualified (see Table 4).

There were no statistically significant effects when the Table VIII scores from the initial and final exercises were analyzed. However, the gunnery practice on Table VII may have improved the scores on the initial crew qualification run to a level that would mask a transfer effect to the first run during the final exercise.

Table 7

Mean and Standard Deviation (SD) of the Initial and Final Live-Fire Overall Performance Criteria for Each Group on the First Run

Table	Control Mean	Control *SD*	Quarterly Mean	Quarterly *SD*	Monthly Mean	Monthly *SD*
			Total Points			
Initial VII	706.0	25.4	666.0	59.2	690.8	96.2
Initial VIII	703.5	120.7	777.0	109.2	696.5	80.1
Final VIII	649.8	141.4	810.8	70.0	769.5	85.5
			Go Engagements			
Initial VII	5.00	0.0	5.25	1.3	5.25	2.2
Initial VIII	6.50	0.6	6.75	2.4	5.50	1.3
Final VIII	5.75	2.5	7.75	1.7	6.50	1.9

Note. There were 4 crews in each group.

When the Table VII data were used as the initial score, there was a significant interaction effect (F (2, 9) = 4.32, p < .05) that indicates the FWS was effective for gunnery training (see Figure 5). There were no statistically significant differences between the groups during the initial live-fire, but there were significant differences between the quarterly and the control group performance during the final exercise. Both experimental groups showed improved gunnery performance while the control group showed a decay in gunnery proficiency.

Go engagements. Both practice on Table VII and FWS training increased the average number of go engagements on the first runs at Table VIII (see Table 7 and Figure 6). The more experienced aviators in the monthly training group did not benefit as much from the Table VII practice as aviators in the other two groups, but they showed an increase in performance as a function of FWS training that was identical to the quarterly group aviators. Only the control group

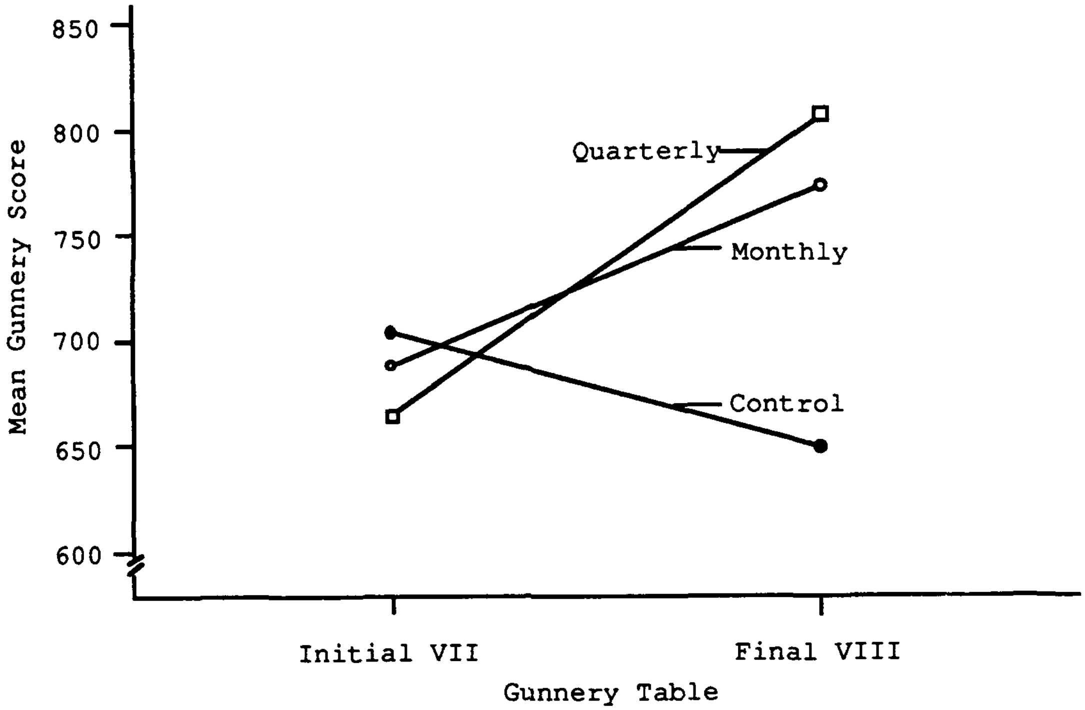

Figure 5. AH-1 scores on the first run (initial Table VII and final Table VIII) for the three training groups.

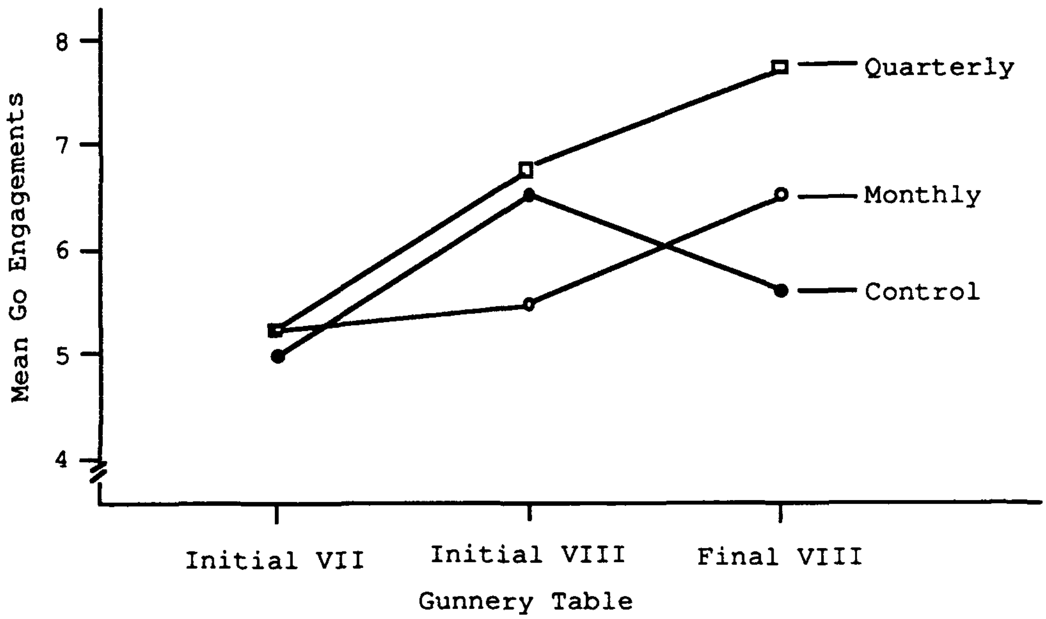

Figure 6. Number of go engagements on the first run (Tables VII and VIII) for the three training groups.

showed a reduction in performance between the initial and final first runs on Table VIII. However, none of the changes in performance for any single training group were statistically significant.

Despite the reduced performance of the control group during the final exercise, there was a statistically significant increase in performance from the initial Table VII to the final Table VIII (F (1, 9) = 7.04, $p < .05$). The overall improvement in the number of go engagements could be attributed to differences between Tables VII and VIII, to the effects of firing Table VIII during the initial exercise, to other types of training (e.g., dry fire), or to the FWS training. Although the interaction effect for go engagements was not statistically significant, the trends shown in Figure 6 are in the appropriate direction to support using the FWS for gunnery training. As noted in the introduction to the Results section, the small sample size and the relatively high variability in performance within groups make it difficult to demonstrate statistical significance unless the underlying effect is very large.

First Run Component Points

Similar analyses were conducted using the average points awarded for engagement time, exposure time, and target effect for each engagement during the first runs on Table VIII. Average component points for Table VII were not included because of differences in the engagements (e.g., no missile engagement on Table VII).

Over all conditions, the crews attained an average of 83.0% of the maximum score for engagement time and 85.7% of the maximum score for exposure time, indicating that their performance on the two speed criteria was quite high (see Table 8). The two experimental groups received significantly higher scores than the control group for both engagement time (F (2,9) = 5.92, $p < .05$) and exposure time (F (2,9) = 10.96, $p < .05$). All groups had significantly better engagement times during the final exercise (F (1,9) = 10.28, $p < .05$); presumably, practice during the initial exercise and either the unit training or FWS training improved their gunnery procedures skills.

However, the absolute differences between the groups for both time measures and between the initial and final exercise for engagement time are very small and the variances within cells are also very small: The coefficients of variation (the standard deviation divided by the mean) range from 2.1%

Table 8

Mean and Standard Deviation (SD) of the Initial and Final Live-Fire Component Scores for Each Group on the First Crew Qualification Run

Table	Control Mean	Control SD	Quarterly Mean	Quarterly SD	Monthly Mean	Monthly SD
Engagement Time Points						
Initial	10.25	0.3	12.55	1.6	12.33	1.7
Final	11.98	1.5	13.63	1.1	13.98	0.7
Exposure Time Points						
Initial	19.15	0.4	22.48	1.0	22.43	1.7
Final	20.08	2.7	21.75	1.2	22.70	1.2
Target Effect Points						
Initial	40.95	12.0	42.68	10.0	34.90	6.9
Final	32.93	11.5	44.25	4.1	40.28	8.5

Note. There are 4 crews in each group. The scores are the average points per engagement.

to 13.3% for engagement time and from 2.8% to 14.0% for exposure time. The low variances probably reflect a ceiling effect. That is, all the crews performed so close to the maximum that there was little variation in their time scores. More importantly, there was neither a significant interaction effect nor a trend toward an interaction that would indicate either a positive or negative transfer of training for the speed components of gunnery skills.

Over all conditions, the crews attained an average of 65.6% of the maximum score for target effect, indicating that their performance on the accuracy criterion was only moderately high (see Table 8). There were no significant main or interaction effects for target effect, probably because of the relatively high variance within cells: Except for the quarterly group on the final exercise, the coefficient of variation for target effect ranged from 19.9% to 35.0%.

The target effect results do exhibit trends that are supportive of using the FWS for gunnery training (see Table 8). The performance of the control group decreased from the initial to final exercise by approximately 20% while the performance of the FWS trained groups either stayed nearly the same or improved. The performance of the quarterly group improved by less than 4%, but the monthly group improved by more than 15%.

First Run Points for Each Weapon System

The third set of analyses evaluated the effect of FWS training for the gun, rocket, and missile weapon systems. The data used in each analysis were the average points scored for all the engagements by each weapon system. Combined engagement points were partitioned into the points awarded for each weapon system.

20 mm gun system. The average points scored on 20 mm gun engagements during the initial Table VIII run indicate a moderate level of performance (see Table 9). There were no significant differences in performance between the groups during the initial exercise, although the monthly training group scored about 16% lower than the average of the other two groups. There was a significant interaction between the groups and exercises (F (2, 9) = 4.57, p < .05). Both FWS training groups improved their average performance while the control group performance decreased (see Figure 7). There was no significant difference between the two FWS groups during the initial or final exercise, and both groups improved their performance by approximately 12 points. The control group performance decreased by a similar amount.

2.75 in. rocket system. The average points scored on rocket engagements during the initial Table VIII run indicate a relatively high level of performance, averaging about 86% of the maximum obtainable score. The average initial scores for the three training groups are also very similar (see Table 9). Performance decreased for all three groups during the final exercise, although the monthly training group's performance only decreased by approximately half as much as the other two groups. None of the effects were statistically significant, but the within cell variation was relatively high.

Table 9

Mean and Standard Deviation (SD) of the Initial and Final Live-Fire Weapon System Scores for Each Group on the First Crew Qualification Run

Table	Control Mean	Control *SD*	Quarterly Mean	Quarterly *SD*	Monthly Mean	Monthly *SD*
			20 mm Gun Points			
Initial	73.90	11.7	69.40	19.1	60.15	5.3
Final	61.15	15.0	81.90	5.2	72.55	7.6
			2.75 in. Rocket Points			
Initial	83.50	15.6	88.81	14.2	87.63	12.7
Final	69.00	16.9	73.25	7.8	80.06	14.2
			TOW Missile Points			
Initial[a]	---	--	---	--	---	--
Final	68.00	40.4	94.75	1.7	86.50	13.3

Note. There are 4 crews in each group. The scores are the average points per engagement. TOW = tube-launched, optically-tracked, wire-guided.

[a]Data from the initial missile engagements are unreliable.

Although not statistically significant, the pattern of results for the rocket engagements could be interpreted to mean the FWS cannot sustain rocket proficiency. That is, the performance of all groups declined in the absence of live-fire practice. However, practice effects and ammunition characteristics are more likely explanations of both the high and similar initial performance levels and the subsequent decline in rocket proficiency. During the initial exercise, all the crews had just practiced firing the rocket system on Table VII and they fired multipurpose submunition (MPSM) rockets, which are more accurate than other types of rockets. For example, the scoring standards in FM 1-140 are higher

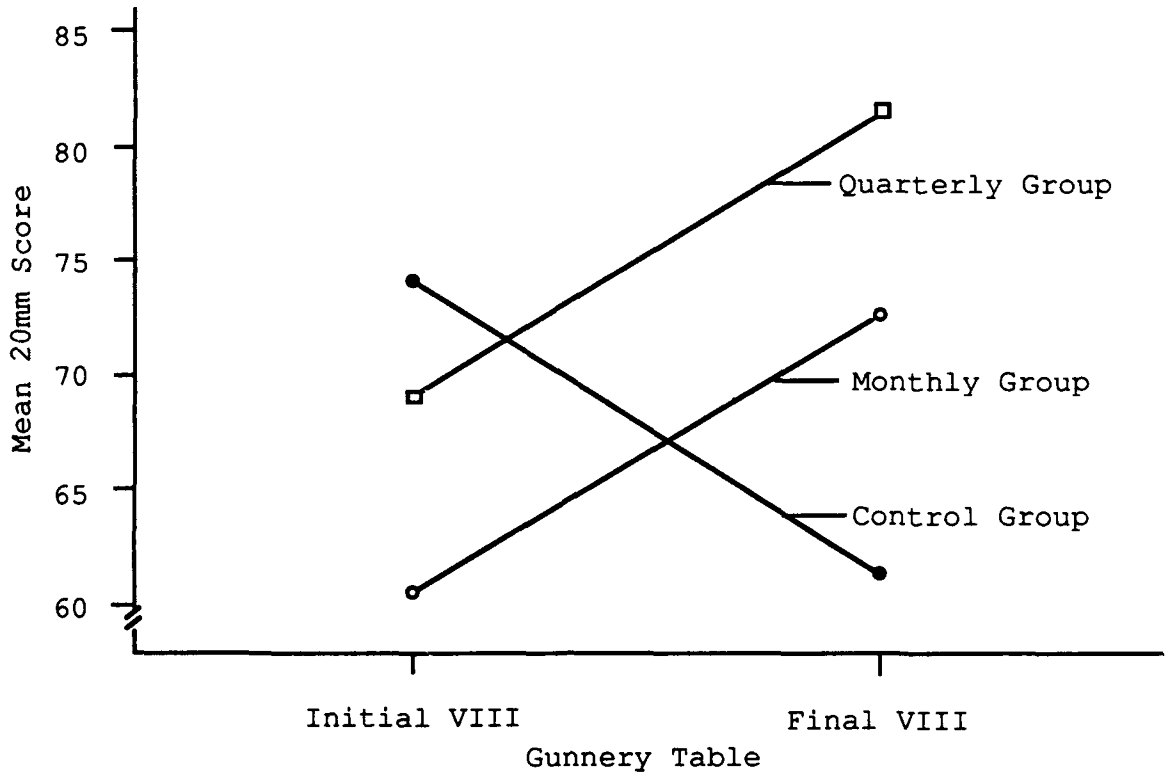

Figure 7. Mean 20 mm gun scores on Table VIII during the initial and final exercises.

when MPSM rounds are being fired. During the final exercise, Table VII was not fired before the crew qualification run and the crews used high explosive (HE) rockets instead of MPSM rounds.

When the Table VII practice and the type of ammunition fired are considered, the only notable (although not significant) difference in performance is the smaller decrease in performance for the monthly training group. This difference may be attributable to either their slightly higher experience levels (see Table 4) or to their more frequent FWS training.

TOW missile system. The TOW missile engagement data could not be analyzed statistically for two reasons. First, the crews fired the missiles during the initial exercise from 200 m beyond the wire length of the rounds they were issued. The crews expected to receive standard wire-length missiles but were issued practice rounds instead. The missiles were, therefore, unguided during the terminal stage of the engagement. Second, the variances of the three groups during the final exercise are significantly different (C (3, 4) = .901, p <.01). The variance within the FWS groups was very small compared to the control group (see Table 9).

Although the initial exercise data were not reliable and the points scored data cannot be analyzed statistically, there were dramatic differences in group performance during the final exercise (see Table 9). All the FWS trained crews hit the moving target with the TOW missile and received at least 14 of the 15 points obtainable for engagement time. Only one of the control crews performed as well; one control crew missed the target, one crew exceeded the minimum engagement time, and the remaining crew fired two missiles that were judged to be malfunctions (they hit the ground less than half way to the target). Whether the malfunctions were due to missile failure, weapon system failure, or crew error could not be determined.

Certainly, the superior missile performance by the FWS trained crews and the problems encountered by the control crews imply that the FWS training is beneficial for either acquiring or sustaining missile proficiency. Whether the experimental crews acquired new skills or sustained existing skills cannot be determined without reliable baseline data. There also could be differences in the initial proficiency levels, but the general equivalence of the three groups on the other measures indicate that this is unlikely. The implication of the observed trends, however tentative, is important because of the high cost of each TOW missile and the minimal amount of live-fire missile practice that has been funded in the past.

Total Qualification Criteria

All crews fired Table VII only once during the initial exercise, but they fired Table VIII during both the initial and final exercises as many times as required to qualify on crew gunnery. If a crew failed to qualify on the first run at Table VIII, points were no longer counted; they only had to achieve seven go engagements. Three measures were analyzed as indexes of performance across all runs: number of runs required to qualify on Table VIII, number of engagements required to qualify on Table VIII, and number of rockets required to qualify on Table VIII. Because of the need to estimate the ammunition requirements for qualification, the rockets fired on Table VII are included in the rockets fired to qualify measure during the initial exercise.

Runs to qualify. During the initial exercise, all the control crews qualified on the first run on Table VIII; half the crews in each of the experimental groups required two runs to qualify (see Table 10). During the final exercise, three quarterly crews and two monthly crews but only one control crew qualified on the first run. The remaining experimental crews all qualified on the second run. One of the remaining control crews qualified on the second run and the other two crews required three runs to qualify. Although not statistically significant, there is a consistent trend indicating that FWS training is beneficial to sustaining overall gunnery proficiency.

Table 10

Mean and Standard Deviation (SD) of the Initial and Final Live-Fire Crew Qualification Criteria for Each Group

	Control		Quarterly		Monthly	
Measure	Mean	SD	Mean	SD	Mean	SD
			Runs to Qualify			
Initial VIII	1.00	0.0	1.50	0.6	1.50	0.6
Final VIII	2.25	1.0	1.25	0.5	1.50	0.6
			Engagements to Qualify			
Initial VIII	10.00	0.0	13.50	4.1	12.50	3.0
Final VIII	16.25	4.8	11.75	3.5	13.25	3.8
			Rockets Fired to Qualify			
Initial Both	32.00	2.3	38.75	6.4	35.00	6.2
Final VIII	25.25	9.3	14.50	5.3	19.00	7.4

Note. There are 4 crews in each group.

Engagements to qualify. The results are very similar (r = .98) for the engagements to qualify criterion: The control crews required more engagements to qualify on Table VIII during the final exercise and the experimental crews required approximately the same number of engagements on both exercises (see Table 10). The similarity in results is not surprising because additional engagements are required on each run. The data were analyzed because the crews only fired the engagements they had failed on the preceding runs, thus producing a more continuously distributed and possibly a more sensitive measure of performance differences than the number of runs to qualify. However, the results and their interpretation are identical for the two measures.

Rockets fired to qualify. Because of the rockets expended on the practice table during the initial exercise, all three groups required significantly fewer rockets to achieve crew qualification during the final exercise (F (1, 9) = 33.49, p <.001). Although the interaction was not statistically significant, both groups of FWS-trained crews showed a much larger drop in the number of rockets required to qualify on the final exercise than the control group (see Table 10).

When the rockets fired on Table VII are excluded, the two experimental groups required approximately the same number of rockets during the initial and final exercises while the control group required over twice as many rockets on the final exercise (see Figure 8). Part of the increase in rocket requirements during the final exercise may be attributed to using HE instead of MPSM rockets, but this effect applies equally to all groups. The reduction in rockets required by the quarterly training group may be a result of continued improvement from their initial low baseline of prior gunnery qualification. Overall, the trend in rocket requirements for qualification support the use of the FWS for gunnery training.

Ammunition Requirements

An absolute assessment of the annual ammunition requirements for training AH-1 gunnery skills cannot be made with the data obtained in this research project. The research was not designed to collect data about individual or initial crew acquisition training requirements, about night training requirements, or about advanced training requirements, such as platoon, company, or combined arms training. In addition, all the crews participated in a combined arms live-fire exercise (CALFEX) approximately 11 months before the final exercise for this project. Reliable data are not available to indicate how

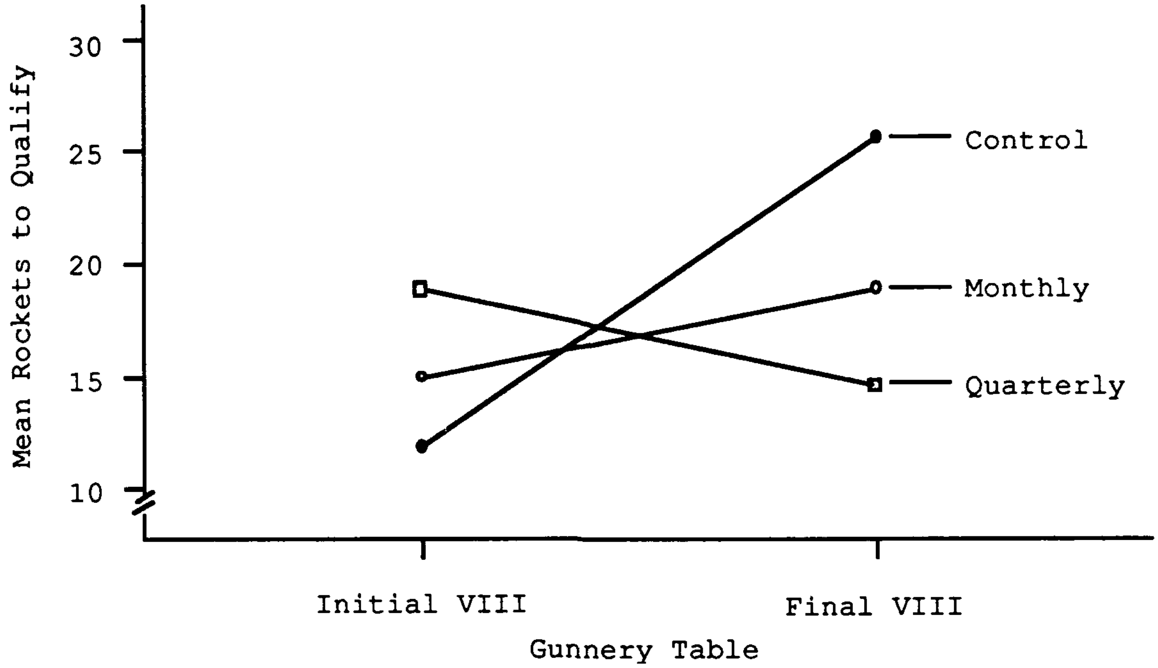

Figure 8. Rockets required to qualify on Table VIII during the initial and final exercises.

much ammunition each crew expended during the CALFEXs; presumably, all crews received approximately equal amounts of gunnery practice.

The data collected during this experiment are not precise enough to make relative assessments of the amount of 20 mm rounds and TOW missiles needed to sustain AH-1 crew gunnery proficiency under the different training regimes. The number of 20 mm rounds expended at any one target and each crew's 20 mm target effect could not be measured precisely without additional instrumentation, such as an area weapon scoring system. Fortunately, the 20 mm ammunition is relatively inexpensive so that it can be used for training in fairly large quantities. Conversely, the TOW missiles are so expensive that they can be fired only for familiarization, not training, purposes. The results indicate only that TOW missile performance was better if the crews received FWS training, not whether familiarization firing is beneficial for sustaining TOW proficiency.

The data collected during this experiment can be used to make practical, relative assessments of the number of rockets required to sustain AH-1 crew gunnery proficiency as a function of the different training regimes. First, the number of rockets fired can be easily counted and performance with the rocket system can be readily scored without additional instrumentation. Second, the rockets are inexpensive enough that they can be fired for practice but are too expensive to be used in large quantities.

The data in Table 10 indicate that an average of approximately 25 rockets (the control group requirements during the final exercise) will be required to sustain the gunnery skill qualifications of a proficient AH-1 crew that does not use the FWS for gunnery training. This estimate implies that the number of rockets expended using both Tables VII and VIII (approximately 35 per crew) was more than the minimum required for qualification. If the crews use the FWS for gunnery training, the number of rockets required for qualification are likely to be even less: The average FWS crew fired approximately 17 rockets to qualify on the final exercise.

The estimates of rocket requirements must be considered in context. The estimates are based on limited data; they do not consider other training requirements; they do not include ammunition fired during other exercises or to maintain the weapon system; and they do not consider the effect of different qualification criteria, which is discussed in the next section. What they do demonstrate is the relative requirements for crew qualification under different training regimes. The data indicate that FWS training improves the gunnery proficiency of the AH-1 crews and at a lower cost. FWS training does not, however, completely replace live-fire training because some of the experimental crews did not qualify on the first run.

Qualification Standards

Finally, the performance of all the crews was tabulated for each firing position to evaluate the standards established for AH-1 gunnery qualification. Table 11 shows for each firing position the engagements fired, the number of attempts, the mean and standard deviation of the crews' performance, and the number of crews that received a go rating on the first run and on all runs. Combined engagements were fired at positions 3, 4, and 5. Although the engagement and exposure times were scored collectively for the combined engagements, dividing the mean performance by two at these positions approximates the same scale as the single engagement firing positions. Additional information about each engagement was presented in Tables 1, 2, and 3.

Table 11

Gunnery Performance by all Crews at Each Firing Position

FP	Eng	n	Mean	SD	1st Go	All Go
1	1	16	72.9	27.5	7	10
2	2	13	87.5	18.4	11	12
3	3/4	20	140.7	43.4	6	8
4	5/6	15	169.5	21.8	9	11
5	7/8	17	157.3	24.0	6	8
6	9	20	46.1	23.4	1	4
7	10	13	74.8	34.0	10	10

Note. FP = firing position; Eng = engagement; n = number of times each engagement was fired; 1st Go = number of crews that received a go rating on the first run; All Go = number of crews that received a go rating on all the runs.

Four effects are obvious in the firing position results (see Table 11). Three of the effects involve single engagements; the fourth effect involves differences among the combined engagements.

Single engagement effects. First, engagement 2 is very easy: The mean score is the highest (87.5% of the maximum) of any engagement, the variability of the scores is lower than on any other engagement, 11 crews received a go on the first run, and it was the only engagement on which all the crews received a go rating (the 12th crew received a go on the second run). Engagement 2 employed the 20 mm gun aimed with the TSU at a range of 1000 m under moderate time standards (see Table 2). Evaluated alone, the aspect or combination of aspects that make engagement 2 less challenging than the other engagements cannot be determined from the available data. However, the distance to the target, which is as long as or longer than any of the other 20 mm engagements, is probably the most difficult aspect of the engagement.

Second, engagement 9 is very difficult: The mean score is the lowest (46.1% of the maximum) of any engagement, only one crew received a go on the first run, and only four crews received a go rating across all runs. Engagement 9 also employed the 20 mm gun, but it was aimed with the pilot's helmet sight at a range of 500 m under the most restrictive time standards (see Table 2). The results of engagements 2 and 9 indicate that the sight system used and the time standards are probably critical in determining the difficulty of the 20 mm single engagements.

Third, the crews were highly proficient in employing the TOW missile system on engagement 10, especially if they had received FWS training. The relatively low mean score is primarily caused by the one control group crew that failed to hit the target and another control group crew that hit the target but exceeded both time standards. The 91% success rate (disregarding the TOW missile attempts that malfunctioned) on the first run was the second highest of all the engagements despite being the only engagement that used a moving target.

Combined engagement effects. Finally, there are differences in performance on the combined engagements. The mean points scored at firing position 3 was lower than at the other two positions (see Table 11). In addition, the crews received more go ratings at firing position 4 than on the other two combined engagements: 6 versus 9 on the first run and 8 versus 11 on all runs. All three combined engagements had identical time standards and employed direct rockets in combination with the 20 mm gun. The primary differences were in the 20 mm sight system used and in the range to the targets (see Table 1).

The greater difficulty experienced at firing position 3 is probably attributable to using the CPG helmet sight to aim the 20 mm gun. Problems in aiming with a helmet sight are consistent with the possible cause of difficulty on engagement 9. Another potential problem at firing position 3 may be the ranges to the targets, either individually or in combination. The range to the rocket box is the longest of any direct rocket engagement and the range to the 20 mm targets is the shortest of any 20 mm engagement. Either target may have been outside the optimal range for the respective weapon system, or the disparity in distances to the targets may have affected the crews' performance.

The higher level of performance at firing position 4 is more difficult to interpret. Probably, it is the combination of all the aspects that facilitate performance on this engagement. The TSU is used to aim the 20 mm gun at firing position 4 (and 5) and the ranges to the targets are at intermediate distances for both systems. The ranges at firing position 5 are the shortest of any rocket engagement and tied for the longest 20 mm engagement.

There is no evidence that the FWS training affected the crews' performance on the combined engagements beyond its effects on using the individual systems. However, combined engagements are difficult to simulate in the FWS because only one target can be active at a time. During the scenarios, combined engagements were actually practiced as sequential engagements from a single firing position. The scout gave a single handover of both targets, but the AH-1 crew could not engage the targets simultaneously.

Use of the firing position results. There are two potential users of the firing position data. First, units in USAREUR can use the information to adjust the crew qualification table designed for their range or to revise their training programs. Effective training and reasonable standards should be reflected in satisfactory and consistent crew performance across engagements, especially for each weapon system. If performance on an engagement is very high and inconsistent with performance on other engagements (e.g., engagement 2), crew skills are probably not tested adequately. The crew and unit commander are therefore receiving inadequate and possibly erroneous feedback about the crew's proficiency. The lack of appropriate information may confirm inappropriate techniques, preclude needed remedial or enrichment training, and ultimately affect the mission effectiveness of the crew and unit.

If performance on an engagement is very low and inconsistent with performance on other engagements (e.g., engagement 9), either the standard is unreasonably difficult or the crew is inadequately trained for the engagement. Regardless of the reason, unsuccessful crews may become frustrated, lose self-confidence, and develop undesirable techniques to meet the standards. For example, if the time standards are too strict and the crew must hurry the engagement, they may use improper switchology, fly unsafely in unmasking and remasking, fire without aiming sufficiently, or disregard the range safety restrictions (i.e., target azimuths). If the crewmembers are inadequately trained, they are likely to employ trial and error in performing the engagement, which both wastes training resources and risks crews adopting improper or less than optimal techniques. In either case, the training value of the crew qualification exercise is diminished.

Second, the firing position information can be used to evaluate the Army's current AH-1 crew qualification standards published in TC 1-140 (USAAVNC, 1990). The notional crew gunnery qualification standards are established by the USAAVNC on the basis of numerous criteria, such as the effective area of the ammunition, unit mission readiness levels, design limitations of the individual weapon system, and the resources available for training. The results of the qualification standards analysis are generally supportive of the criteria established in TC 1-140. Specifically, adjustments are apparently made to the performance standards on the AH-1 crew qualification table as a function of the weapon system, sighting system, and distance to the target.

Only indirect inferences can be drawn about the absolute difficulty of the Army-wide standards because there are substantial differences between the Table VIII used in this project and the day crew qualification table in the current gunnery manual, TC 1-140. The gunnery table used for crew qualification in this research was developed by the unit SIPs on the basis of the then current helicopter gunnery manual, FM 1-140, and the constraints of the USAREUR range. The three differences between the tables that are most likely to affect whether a crew qualifies are the aircraft firing mode, the ranges to the target, and the target effect standards.

TC 1-140 calls for hovering, running, and diving fire engagements on Table VIII. Because the USAREUR crews only fired from a hover, data are not available to determine the effect that firing in the other modes would have on crew proficiency or on the amount of ammunition required to qualify. The distances to the targets were generally shorter in the USAREUR exercise than listed in TC 1-140. Presumably, firing from greater distances would have a negative effect on crew proficiency and would necessitate additional practice, at least for the 20 mm gun (Hamilton, 1991). Finally, the box dimensions for scoring area weapon target effect are generally smaller than the USAREUR dimensions, especially for the rocket engagements. Imposing more rigorous target effect standards would definitely lower the observed crew proficiency ratings and would require additional ammunition and training for gunnery qualification.

Summary and Conclusions

The primary purposes of this research were to evaluate the effectiveness of the AH-1 FWS for sustaining crew gunnery skills and to determine the optimal amount of FWS training needed to sustain those skills. Two additional research objectives were to estimate the ammunition requirements for sustaining crew qualification and to evaluate the standards for qualifying on crew gunnery.

The research was conducted as a field experiment using a standard transfer-of-training design with operational unit aviators serving as subjects. One group of aviators continued their normal unit training while two groups of aviators received different amounts of FWS training using gunnery scenarios specifically developed for this project. While attempting to collect valid scientific data about the training of helicopter gunnery, every attempt was made to minimize any negative effects on the unit training programs (e.g., excessive paperwork, loss of flight proficiency) and to maximize any positive benefits that the crews may have received from their participation (e.g., additional ammunition to fire on the range).

Since the project began, numerous problems have been encountered that delayed its completion and limited the amount of information that could be obtained from the data. The most serious of these problems were the involuntary extension of the project and the attrition of participating aviators. Fortunately, however, the project extension applied to all participants and the loss of crews occurred equally across the three training groups: The characteristics of the aviators who completed the project were generally equivalent across groups when the experiment began. Although a larger sample and better experimental control are desirable, the results provide consistent and interpretable information about the research objectives. The information obtained in this project is especially important because of the lack of other relevant research; the high cost of simulators, aircraft, ammunition, and other training resources; and the need to maintain a proficient attack helicopter force.

FWS Training Effectiveness

The results provide evidence that AH-1 gunnery skills do decay without practice and that the FWS is moderately effective in sustaining AH-1 gunnery skills. Although there were no significant differences between the groups on the initial exercise, the FWS-trained crews performed better than the control group crews during the final exercise. Compared to the control group, the experimental groups had significantly higher scores on the first run, had a larger percentage of qualifications on the first run, and had fewer requalification runs for the crews who failed on their initial attempt. Performance by the experimental group crews generally improved between the two exercises while the performance of the control group crews generally declined.

The FWS training appeared to affect the accuracy of the crews' gunnery performance more than the speed, but the results of the performance components analysis are not conclusive.

The FWS training effectiveness conclusion applies to all three weapon systems on the AH-1. There was a significant interaction for the 20 mm gun that demonstrated improved performance by the experimental group crews and decreased performance by the control group crews. Although the performance results for the rocket system are somewhat complicated by the Table VII practice effects and the different type of rocket used in the two exercises, the experimental crews required fewer rockets than the control crews to qualify on the final exercise. Finally, the TOW missile performance also supports the effectiveness of the FWS training, even though the data could not be analyzed statistically: All the experimental crews but only one of the four control group crews performed satisfactorily on their missile engagements.

Although the results support the use of the FWS for AH-1 gunnery training, they do not indicate that FWS training can replace live-fire gunnery training. Compared to the control crews, a larger percentage of the experimental crews qualified on the first run during the final Table VIII exercise, but none of the groups achieved 100% qualification on the first run. Instead of replacing live-fire exercises, the FWS should be used to augment the unit gunnery training program. The FWS can help sustain gunnery skills between range exercises and probably enables better utilization of the limited range time and ammunition resources available to each unit. That is, FWS training should reduce range errors in switchology, crew coordination, and other procedures so that the crew can concentrate on the gunnery aspects that are best practiced on the range, such as estimating distances to targets and performing combined engagements.

Amount of FWS Training

The results are less conclusive about the optimal amount of FWS training required to produce gunnery proficiency. On the final exercise, the crews who received quarterly FWS training generally performed slightly better than the crews who received monthly training, but there was never a statistically significant difference between the two experimental groups. This overall result implies that quarterly FWS training is sufficient to sustain gunnery skills at the maximum possible level between live-fire exercises. It also implies that more frequent FWS training is at least not productive and at worst counterproductive.

Two mitigating factors should be considered before drawing a conclusion, based on these implications, about the optimal amount of FWS training. The more objective factor is the length of time between the last FWS training session and the final gunnery exercise. All the experimental crews conducted their last FWS session, the Table VIII range scenario, within 3 weeks of the final range exercise. The statistically equivalent performance by the two groups may be a function of how recently they received FWS gunnery training rather than how much FWS training they had received over the preceding 15 months. Unfortunately, the sample size was too small to include a recency factor in the research design.

The more subjective factor is the assumption of initial equivalence between the quarterly and monthly groups. There is some evidence in the data that the observed performance differences may be due to the quarterly group crews being more talented but less well trained initially than the monthly group crews. Before the initial live-fire exercise, all the crews were approximately equal in prior military and flight demographics (see Tables 4 and 5). However, all the monthly group crews were qualified on crew gunnery, but only 57.1% of the quarterly group aviators had previously qualified. In addition, the quarterly group crews showed substantially more improvement than the monthly group crews in their initial Table VIII performance as a result of practice on the Table VII run (see Table 7 and Figure 6). For example, the quarterly group scored 3.6% fewer points than the monthly group on Table VII but scored 11.6% more points on Table VIII. Finally, both groups showed approximately equal improvement in performance on the final Table VIII as a result of their FWS training. For example, both groups showed equal improvement in their 20 mm gun performance from the initial to the final exercise (see Table 9 and Figure 7).

Given these considerations, the data support the qualified conclusions that quarterly FWS training is as effective as monthly training in sustaining crew gunnery skills, and that more frequent training does not have any negative transfer effects. The data are inadequate to determine what effect the recency of training has on live-fire performance. After a 3-month lapse in FWS practice, the crews that received quarterly FWS training might exhibit a loss in gunnery proficiency. In addition, the data do not address the issue of whether the FWS training can sustain crew gunnery performance over longer periods of time, such as over 5 years instead of 15 months.

Ammunition Requirements

The data collected in this experiment provide only limited information about the absolute ammunition requirements to sustain gunnery skills because many aspects of helicopter gunnery training (night, combined arms, etc.) were not assessed and because of the limitations on measuring crew performance without an area weapons scoring system (cf. Hamilton, 1991). However, two conclusions can be drawn from the available data. First, the current ammunition allocations in the 1990 Standards in Weapons Training Manual (Department of the Army Pamphlet 350-38) are near the minimum needed for AH-1 crew qualification, especially if the aviators are to be qualified in both crew stations. Second, FWS training can reduce the ammunition requirements for qualification slightly, but its greatest benefit is probably in increasing the effectiveness of the live-fire training.

Qualification Standards

Finally, the data collected in this experiment lead to two specific conclusions about the USAREUR standards for qualification and two general implications for the Army-wide standards. First, single engagement 20 mm proficiency using the TSU is inadequately tested by the USAREUR Table VIII. Second, 20 mm pilot helmet sight gunnery in USAREUR is either inadequately trained or the standards for qualification are too difficult.

For the Army-wide implications, the data support the variations in performance criteria published in TC 1-140 for different aspects of each weapon system (e.g., sight system, type of rocket) and different firing conditions (e.g., range to the target). However, the performance levels exhibited by the USAREUR crews cannot be directly applied to the Army-wide standards, which are more demanding than the USAREUR standards. Compared to the USAREUR standards, the TC 1-140 standards require the crews to fire more combined engagements, to fire from greater distances, to hit smaller target boxes, and to include running and diving fire in the evaluation. As mentioned in the summary of ammunition requirements, the data collected in USAREUR only address day crew qualification standards. Therefore, no conclusions can be drawn about the other standards in TC 1-140.

Recommendations

The data collected in this experiment provide important information about AH-1 gunnery training and lead to five recommendations related to the research objectives. First, the FWS should definitely be included in the unit's gunnery training program, but only as one component of the program. The research demonstrated both the effectiveness of the FWS for gunnery training and its limitations for sustaining crew proficiency. The FWS training improved the crews' gunnery proficiency and produced a small savings in ammunition resources, although those resources should probably be shifted to higher levels of training (e.g., company, combined arms) rather than eliminated from the training program. However, FWS training alone was not sufficient to sustain the gunnery qualification skills of all the experimental crews.

Second, units should routinely schedule FWS gunnery training for each crew at least once a quarter and at least within one month of a live-fire exercise to maximize the benefit of the simulator training. More frequent FWS gunnery training (e.g., for less experienced or less proficient crews) may be conducted without concern for negative transfer from the simulator to the aircraft.

Third, well developed scenarios should be used to obtain the maximum benefit from the FWS training. Although comparative data were not collected in this experiment, anecdotal information collected in previous FWS experiments indicate that some crews and IPs are not aware of the many instructional features of the FWS or do not spend enough time preparing for the training to gain the maximum benefit. In effect, they are logging time rather than receiving effective training. The nine training scenarios developed for this research project are available for AH-1 units and FWS facilities to use or adapt for their gunnery training.

Fourth, the ammunition allocated for AH-1 gunnery training should not be substantially reduced from current levels, at least until additional research is conducted. The additional research should address the effectiveness of the FWS for other types of gunnery training, the interaction between simulator, dry-fire, and live-fire training at all levels (individual, crew, team, and combined arms), and the effects of long-term training in the simulator. In addition, the ammunition required to qualify on the USAREUR Table VIII is probably less than the amount that would be required to qualify on the Army-wide standards. The primary benefit of FWS gunnery training is increased proficiency, not reduced training costs.

Fifth, both USAREUR and the USAAVNC should examine the standards imposed for qualification and their implications for training and training resources. The USAREUR table may not be assessing some gunnery skills adequately and may be setting unreasonable standards for other skills. Primarily because of range constraints, the USAREUR table is less demanding than the notional table established by the USAAVNC. Similarly, the USAAVNC should examine the difficulty of the Army-wide standards and its implications. If the USAAVNC standards are both feasible and necessary for maintaining a qualified attack helicopter force, then more and better gunnery training and more training resources than are currently available are probably needed to meet those standards.

A final recommendation is that further research be conducted to address the training effectiveness of flight simulators for sustaining operational unit aviator skills. There is very little other relevant research and this experiment is limited in the training aspects that could be addressed and in the size of the sample on which these conclusions and recommendations are based. The most critical research needs are (a) to replicate these results with a larger sample under more controlled conditions; (b) to investigate the effects of recency of training, the interaction of simulator and different amounts of live-fire training, and the long-term effects of simulator training; (c) to evaluate the TC 1-140 standards more directly; (d) to evaluate the effects of different types of training scenarios; and (e) to evaluate the effects of FWS training on other criteria (e.g., sustaining normal flight, emergency procedures, tactics, and night gunnery skills).

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APPENDIX A

DIAGNOSTIC GUNNERY SKILLS TEST

DIAGNOSTIC GUNNERY SKILLS TEST

NOTE: The following is a test of your knowledge of gunnery subjects. Read each item carefully. Respond to multiple choice items by placing a check mark [√] in the box to the left of the most correct alternative. Respond to matching items by placing the appropriate number in the space provided to the left. You may take as long as you need to complete this test. Place your name and today's date at the bottom of the first page and your initials on **each page** of this test.

---

1. With TOW AUTO selected on the TCP and a TOW missile on the wire, can the **Pilot fire the 20 mm cannon**?
   1[ ] Yes
   2[ ] No

2. What is the time of flight of a TOW missile at a range of **3,750 meters**?
   1[ ] 15.5 seconds
   2[ ] 28.0 seconds
   3[ ] 20.5 seconds
   4[ ] None of the above

3. Why is the effectiveness of the TOW missile **degraded** at extended ranges?
   1[ ] At extended ranges, the missile accelerates and assumes a nose-low attitude.
   2[ ] The Gunner is not able to distinguish targets at extended ranges.
   3[ ] The Pilot cannot maintain the aircraft within constraints for the length of time required at extended ranges.
   4[ ] At extended ranges, the missile decelerates and assumes a nose-high attitude.

4. How should a Gunner track a TOW target **at night**?
   1[ ] Launch the missile with the TSU off of the target and bring the TSU back on target as the missile flight progresses.
   2[ ] Maintain the TSU on the center of mass throughout the flight of the missile.
   3[ ] Keep the TSU in Lo-Mag for ten seconds after missile launch, then switch to Hi-Mag.
   4[ ] None of the above

Name:__________________

Date:__________________

Initials:_______________

5. What does the **inner circle** of the TSU 2x reticle represent?
   1[ ] Position of the 20 mm gun
   2[ ] Field of view for the TSU on 13x
   3[ ] Pilot's line of sight
   4[ ] None of the above

6. What are the minimum and maximum LASER range readouts?
   1[ ] 0 meters minimum and 3,750 meters maximum
   2[ ] 0 meters minimum and 9,990 meters maximum
   3[ ] 200 meters minimum and 3,750 meters maximum
   4[ ] 200 meters minimum and 9,990 meters maximum

7. What is **the function** of the LASER Range Display switch and rheostat?
   1[ ] They allow the Gunner to set the minimum range that the LASER will recognize.
   2[ ] They allow the Gunner to set the maximum range that the LASER will recognize.
   3[ ] They allow the Gunner to calibrate the accuracy of the LASER.
   4[ ] None of the above

8. The LASER display in the TSU presents several colored indicators. **Match** each colored indicator with its **function description** by placing the appropriate number in the space provided to the left of the indicator color.

_____	a. Steady Red	1. LASER Range Finder Malfunction
_____	b. Steady Green	2. No Valid LASER Return Pulses
_____	c. Flashing Yellow	3. LASER Range Finder Overtemperature
_____	d. Steady Yellow	4. Multiple Targets Detected by LASER Range Finder

9. During slewing of the turret, what is indicated by a **flashing reticle** in the HSS?
   1[ ] The 20 mm gun is inoperative.
   2[ ] A TOW missile is on the wire.
   3[ ] The FCC has failed.
   4[ ] The TSU and 20 mm gun are not in coincidence.

 Initials:_______________

10. What is the correct switchology for a Pilot to Gunner handover using the PHS?

1[ ] ATS switch to ACQ; PHS/ALT switch to PHS

2[ ] ATS switch to TRK; PHS/ALT switch to PHS

3[ ] ATS switch to TRK; PHS/ALT switch to ALT

4[ ] ATS switch to ACQ; PHS/ALT switch to ALT

11. What is the **purpose** of the TSU/GUN SLEW RATE switch in **High slew**?

1[ ] Allows the Gunner to verify proper slewing of the 20 mm gun

2[ ] Allows the Gunner to acquire TOW targets more quickly

3[ ] Allows the Gunner to receive handovers from the Pilot more quickly

4[ ] Allows the Gunner to acquire and engage targets more quickly with TSU GUN

12. What will cause the Pilot In Control light to illuminate in the Gunner's cockpit **regardless of the position** of the Pilot's Weapon's Control switch?

1[ ] TCP Mode switch in STANDBY

2[ ] TCP Mode switch in a TOW mode

3[ ] PHS/ALT switch in PHS

4[ ] a TOW missile on the wire

13. When firing **Indirect** Rockets, the correct release point is achieved by superimposing the FCC Reticle over which point?

1[ ] The Gunner's LOS

2[ ] The target of interest

3[ ] The Boresight Reference

4[ ] None of the above

14. If the radar altimeter is broken, on which altitude will the FCC base rocket solutions?

1[ ] 100 feet

2[ ] 33 feet

3[ ] 0 feet

4[ ] the barometric altimeter reading

Initials:_______________

15. What happens to the HUD flight safety symbology when the Gunner's LOS moves into their position?

1[ ] The safety symbology disappears.

2[ ] The safety symbology flashes.

3[ ] The safety symbology remains constant.

4[ ] None of the above

16. For which airspeed was the Stadiametric Reticle **designed** to provide the **most accurate** information for rocket engagements?

1[ ] 0 KIAS

2[ ] 20 KIAS

3[ ] 70 KIAS

4[ ] 120 KIAS

17. During TOW **prelaunch**, what does a flashing Gunner's LOS inside the prelaunch box indicate?

1[ ] Out of pitch constraints

2[ ] Out of yaw constraints

3[ ] Out of roll constraints

4[ ] Out of altitude constraints

18. What effect does **increasing range** have on the linear dispersion of 2.75" FFAR?

1[ ] As range increases, the linear dispersion increases.

2[ ] As range increases, there is no change in the linear dispersion.

3[ ] As range increases, the linear dispersion decreases.

4[ ] None of the above

19. When making **height of burst** adjustments for flares, how far will a 1° change in pitch attitude shift the height of burst?

1[ ] 400 feet

2[ ] 200 feet

3[ ] 100 feet

4[ ] No appreciable change

 Initials:________________

20. How does **angular rate error** affect a TOW Missile?

1[ ] Causes a TOW missile to precess to the right as it spins in flight

2[ ] Has no appreciable effect on a TOW missile

3[ ] Causes a TOW missile to deflect away from the target when the boreline axis differs from the flight path

4[ ] Causes the TOW missile to drift with the wind as it approaches the target

21. When using LASER ranging, how long will the crew receive range updates **for the 20 mm cannon**?

1[ ] 3 seconds

2[ ] 6 seconds

3[ ] 12 seconds

4[ ] 15 seconds

22. **Match** each ballistic effect with the **most appropriate** corrective action by placing the appropriate number in the space provided to the left of the ballistic effect. Some corrective actions may be used more than once.

_____ a. Projectile Drift	1. Maintain vertical and horizontal trim
_____ b. Trajectory Shift	2. Fire out of ground effect
_____ c. Port-Starboard Effect	3. Ensure accurate boresighting
_____ d. Rotor Wash Error	4. Compensation by aircrew not required; compensated for by FCC
_____ e. Relative Wind	
_____ f. Tube Misalignment	5. Fire in ground effect
_____ g. Terminal Ballistics	6. Select appropriate fuse and warhead types
	7. Ensure tail wind at firing position

23. During diving or running fire, how should the Pilot maintain **vertical trim**?

1[ ] Increase the power setting as the dive progresses.

2[ ] Throughout the dive, maintain a constant power setting with the collective.

3[ ] Throughout the dive, maintain trim with the antitorque pedals.

4[ ] Decrease the power setting as the dive progresses.

 Initials:_______________

24. Prior to loading a TOW missile, the dessicant indicator is blue. What does this indication mean?

1[ ] The missile contains excessive humidity and should not be loaded.

2[ ] The missile contains excessive humidity and should be set in open air to dry.

3[ ] The missile is in a satisfactory condition and should be loaded.

4[ ] The missile motor contains solid fuel propellant.

25. When using LASER ranging **for rocket solutions**, how long will the crew receive range updates for 2.75" FFAR?

1[ ] 3 seconds

2[ ] 6 seconds

3[ ] 12 seconds

4[ ] 15 seconds

26. When using LASER range finding, what happens at the **end of the update time**?

1[ ] The FCC reticle disappears until next LASER input.

2[ ] The System returns to manual range and the FCC reticle stows to the HUD boresight.

3[ ] The FCC continues to update the range *until* the next LASER firing.

4[ ] The System returns to Manual Medium Range regardless of the switch position.

27. Which equation represents the Worms Formula?

1[ ] Range = W/M x 1,000

2[ ] Range = M/W x 1,000

3[ ] Range = 1,000/W x M

4[ ] Range = M/W + 1,000

28. What is the range to a T-72 viewed from the side if it occupies two milliradians in the TSU with Hi-Mag selected?

1[ ] 4,500 meters

2[ ] 4,000 meters

3[ ] 3,500 meters

4[ ] 2,800 meters

 Initials:________________

29. Refer to Figure 1. **Match** the five weapon modes with their corresponding HUD displays by placing the appropriate figure number in the space provided to the left of each weapons mode.

_____ a. Second Rocket Backup Mode

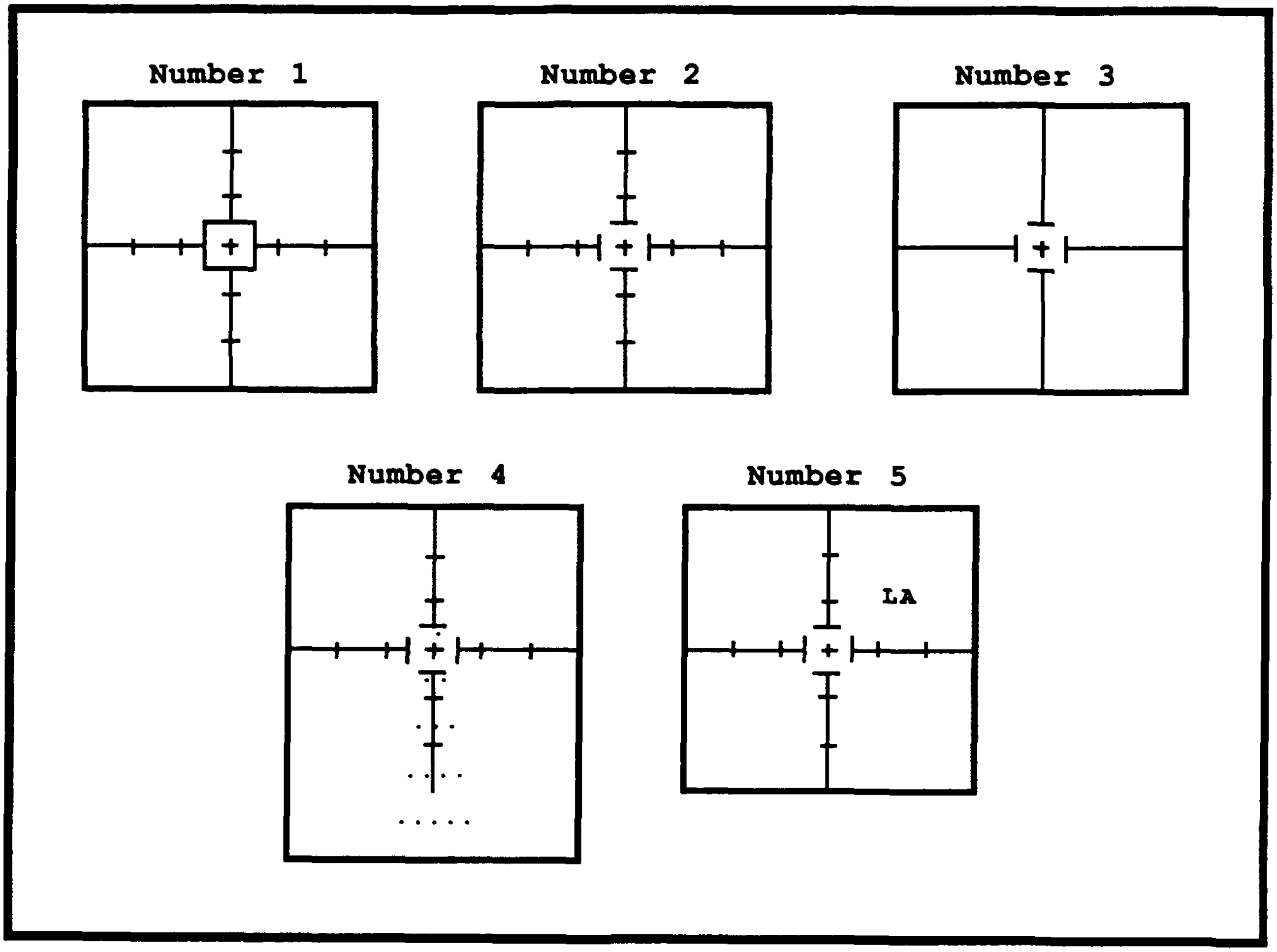
_____ b. First Rocket Backup Mode

_____ c. Rocket Indirect Mode

_____ d. Fixed Gun Mode

_____ e. Rocket Direct Mode

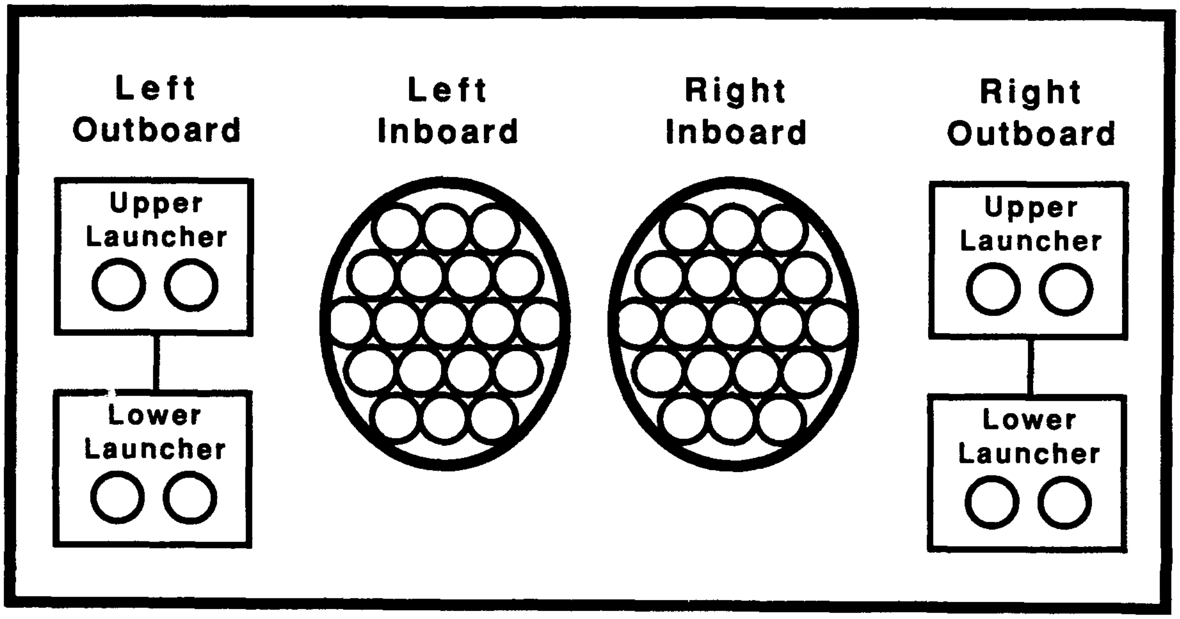
Figure 1. HUD displays for five weapon modes.



 Initials:_______________

30. Refer to Figure 2. Figure 2 presents a rear view of an AH-1F that has four TOW launchers and two M261 Rocket Launcher Pods. Identify the rocket launcher zones and the order in which the eight TOW missiles are launched by **placing the appropriate number in each circle in Figure 2.**

Figure 2. Pods and launchers as viewed from rear.



31. Refer to the table on the following page. Indicate the correct position of all switches required to accomplish each firing task listed in the column "FIRING MODES." If a specific switch is not required to accomplish a task, then leave the block blank. The firing task "20 mm TSU" has been completed as an example.

Initials:________________

FIRING MODES	PILOT SWITCHES								GUNNER SWITCHES											
	ARMAMENT PANEL		CYCLIC GRIP			HUD		RMS	TCP	RIGHT CONSOLE					LEFT HAND GRIP		HAND CONT	INST PANEL	CYCLIC GRIP	
	WPN CONTR	WIND STORE	ACTION	GUN	WING ARM FIRE	RKT	MODE	RNG KM	MODE SELECT	RANGE	PLT ORIDE	WING STORE	TURR DEPR LIMIT	TURR SLEW	ACTION	TRIG-GER	ACQ TRK STOW	ACQ	WING ARM FIRE	ACTION
20 mm TSU	Gunner								TSU/ GUN	Select	OFF		OFF	NORM	Press	Press	TRK			
20 mm GHS																				
20 mm PHS																				
20 mm FIXED																				
DIRECT ROCKETS																				
INDIRECT ROCKETS																				
ROCKETS w/o FCC																				
ROCKETS w/o FCC or LRF																				
TOW PRELAUNCH																				
TOW POSTLAUNCH																				

Initials:________________

APPENDIX B

AH-1 AVIATOR QUESTIONNAIRE

AH-1 AVIATOR QUESTIONNAIRE

Prepared By:

U.S. ARMY RESEARCH INSTITUTE
AVIATION RESEARCH AND DEVELOPMENT ACTIVITY

The Army Research Institute Aviation Research and Development Activity (ARIARDA) is an Army agency located at Fort Rucker, Alabama, that conducts aviation related research for the Department of the Army. ARIARDA has been conducting a research project to determine (a) the training effectiveness of the AH-1 Flight and Weapons Simulator (FWS) for training gunnery tasks and (b) the annual ammunition requirements for training AH-1 aviators assigned to operational field units. This project is entitled the AH-1 Post-Fielding Training Effectiveness Analysis (AH-1 PFTEA).

This questionnaire was completed by all participating aviators before the AH-1 PFTEA began. All participating aviators are now requested to complete the questionnaire again to document any changes that have occurred since you originally completed the form. Your training experiences during the last 6 months are particularly relevant because of the delays in completing the project.

Your responses will be held in confidence and will be used for research purposes only. The identifiers that are requested will be used for administrative purposes and will be separated from your responses to the questionnaire's items. Please sign your name in the space provided below to indicate that you have read this information. Thank you for your assistance in completing this form and for your participation in the AH-1 PFTEA.

Signature: ______________________________

Name (Print): ______________________________

SSN: ___ ___ ___ - ___ ___ - ___ ___ ___ ___

Today's Date: ________ / ________ / ________
(Month) (Day) (Year)

U.S. ARMY RESEARCH INSTITUTE
AVIATION RESEARCH AND DEVELOPMENT ACTIVITY

AH-1 AVIATOR QUESTIONNAIRE

This questionnaire is designed to collect information about your personal background and flight experience. Answer each item that applies to you by checking the appropriate box [√] or by writing the required information in the space provided. When answering items about flight hours, you may refer to records. If records are not available, estimate the number of flight hours as closely as possible. Your responses will be used for research purposes only.

---

1. What is your age ?

   ________ Years

2. What is your current rank?

   1[ ] WO1 5[ ] 2LT
   2[ ] CW2 6[ ] 1LT
   3[ ] CW3 7[ ] CPT
   4[ ] CW4 8[ ] MAJ

3. How long have you been on active duty military service?

   ________ years and ________ months of active service

4. To which unit are you assigned? Fill in the blank and circle the appropriate unit designation.

   ________ = Company/Troop
   ________ = Battalion/Squadron
   ________ = Brigade/Regiment
   ________ = Division

5. How long have you been assigned to your present unit?

   ________ years and ________ months

6. Currently, what is your primary duty position in the unit?

1[ ] Pilot	8[ ] Armament Officer
2[ ] Section Leader	9[ ] Maintenance Test Pilot
3[ ] Platoon Leader	10[ ] Safety Officer
4[ ] Company/Troop Commander	11[ ] Battalion Staff (S1, S2, S3, S4)
5[ ] Instructor Pilot	12[ ] Battalion Executive Officer
6[ ] Standardization Pilot	13[ ] Battalion Commander
7[ ] Instrument Examiner	14[ ] Other (Specify)______________

7. How long has it been since you graduated from initial Army flight training?

   ________ years and ________ months

8. How long has it been since you graduated from the AH-1 Qualification Course?

   ________ years and ________ months

9. Is this your first assignment to an operational unit since graduating from the AH-1 Qualification Course?

   1[ ] Yes
   2[ ] No

10. Which of the following courses, if any, have you completed? [check all that apply]

1[ ] WO Senior	3[ ] Aviation Officer Advanced
2[ ] WO Advanced	4[ ] None of the above

11. Indicate the type of aviator wings that you have.

   1[ ] Aviator
   2[ ] Senior Aviator
   3[ ] Master Aviator

12. Indicate the total number of flight hours you have logged in each of the following aircraft. Also, check [√] the highest qualification you hold in each aircraft.

a. Military Rotary Wing

AH-64: ________ hours [ ] PI [ ] PC [ ] UT [ ] IP [ ] SP
AH-1: ________ hours [ ] PI [ ] PC [ ] UT [ ] IP [ ] SP
OH-58: ________ hours [ ] PI [ ] PC [ ] UT [ ] IP [ ] SP
UH-1: ________ hours [ ] PI [ ] PC [ ] UT [ ] IP [ ] SP
Other: ________ hours [ ] PI [ ] PC [ ] UT [ ] IP [ ] SP
(Specify other aircraft)________________________________

b. Military Fixed Wing

________ hours [ ] PI [ ] PC [ ] UT [ ] IP [ ] SP
[Specify aircraft type(s)]________________________________

13. Are you currently qualified as an instrument examiner?
1[ ] Yes
2[ ] No
If yes, in what aircraft?________________________________

14. During your Army career, how many total flight hours have you logged in the **AH-1 Flight and Weapons Simulator**?
________ hours

15a. Are you currently an AH-1 Instructor Pilot or Standardization Instructor Pilot?
1[ ] Yes
2[ ] No

15b. If yes, how long has it been since you completed the Instructor Pilot Course?
________ years and ________ months

15c. If yes, how many flight hours have you logged as an Instructor Pilot?
________ flight hours

16a. Are you an AH-1 Unit Trainer?

1[ ] Yes

2[ ] No

16b. If yes, on which tasks are you authorized to train other pilots? [check all that apply]

[ ] Contact
[ ] Instrument
[ ] Night Goggles
[ ] Border
[ ] Tactics
[ ] Gunnery
[ ] Academics
[ ] Other (Specify)____________________

17. What is your Flight Activity Category?

1[ ] FAC 1

2[ ] FAC 2

18. What is your current Readiness Level?

1[ ] RL1

2[ ] RL2

3[ ] RL3

19. In which crew duty positions are you authorized to fly?

1[ ] Gunner

2[ ] Pilot

3[ ] Both

NOTE: Questions 20 through 30d request information about your recent flight experience in an operational field unit. Include experience received in all of the operational units to which you have been assigned **during the last six months**. Do not include your experience in flight school or in the AH-1 AQC.

---

20. During the last six months, how many flight hours have you logged in each crew station of the the **AH-1 aircraft**?

a. ________ flight hours in the **pilot crew station**

b. ________ flight hours in the **gunner crew station**

21a. Do you regularly fly another Army aircraft in addition to the AH-1?

1[ ] Yes

2[ ] No

21b. If yes, enter the type of aircraft

________ aircraft type

21c. If yes, enter the total number of hours that you have logged in this aircraft during the last six months.

________ total hours

22. During the last six months, how many flight hours have you logged in the **AH-1 FWS**?

________ flight hours

23. During the last six months, how many **total** flight hours have you logged using **Night Goggles** in each crew station of the AH-1 aircraft?

a. ________ hours in the **gunner crew station**

b. ________ hours in the **pilot crew station**

24. Are you **current with Night Goggles** in the AH-1 aircraft?

1[ ] Yes

2[ ] No

25. During the last six months, how many total hours have you trained using **Night Goggles** in other aircraft?

________ hours

26. During the last six months, how many flight **evaluations** have you had in the AH-1 aircraft?

________ evaluations

27. Excluding evaluations, how many **times** have you flown in an AH-1 aircraft during the last six months?

________ times

28. Excluding evaluations, how many **crewmembers** have you flown with during the last six months?

________ crewmembers

29. Excluding evaluations, how many times have you flown with each of the following crewmembers during the last six months? (The total should not exceed the number entered for Item 27.)

a. ________ times with the most frequent crewmember

b. ________ times with the second most frequent crewmember, if any

c. ________ times with the third most frequent crewmember, if any

30a. Are you battle rostered with a specific crewmember?

1[ ] Yes

2[ ] No

30b. If yes, how many months have you been battle rostered with this individual?

________ months

30c. If yes, how many hours has your crew trained together during the last six months?

a. ________ AH-1 flight hours

b. ________ AH-1 FWS hours

30d. If yes, is your other crewmember the one you flew with most frequently during the last six months? [refer to Item 29]

1[ ] Yes

2[ ] No

31. When did you last fire live ammunition from an AH-1 aircraft?

Date: ________/________/________
(Month) (Day) (Year)

32. On which range did you last fire live ammunition from an AH-1 aircraft?

____

33. Currently, in the AH-1 aircraft, are you qualified on:

a. individual gunnery

1[ ] Yes

2[ ] No

b. crew gunnery

1[ ] Yes

2[ ] No

c. team gunnery

1[ ] Yes

2[ ] No

34. When did you last **qualify** on crew gunnery in the aircraft?

Date: ________ / ________ / ________
(Month) (Day) (Year)

35. When you last qualified on crew gunnery in the aircraft, which crew station did you occupy?

1[ ] Gunner

2[ ] Pilot

3[ ] Both

36. Approximately how many rockets have you fired from an AH-1 since you graduated from the AH-1 Qualification Course?

________ Rockets

37a. Approximately how many TOW missiles have you fired from an AH-1 gunner's crew station since you graduated from the AH-1 Qualification Course?

________ TOW missiles

37b. Of the TOW missiles you have fired, how many hit the target?

________ TOW missiles

NOTE: Items 38 - 41 require that you provide information and opinions concerning your flight proficiency and training. Please answer the questions with regard to **your** skills only.

38. Use the following scale to rate **your** proficiency on each of the tasks listed below. The verbal anchors on the scale refer to the average AH-1 pilot. Do not consider pilots of other types of aircraft. Fill in the blank beside each task with the appropriate whole number between 1 and 9.

1	2	3	4	5	6	7	8	9
Well Below Average Pilot		**Below Average Pilot**		**Average AH-1 Pilot**		**Above Average Pilot**		**Well Above Average Pilot**

a. ________ Rockets - Direct
b. ________ Rockets - Indirect
c. ________ Rockets - Stadiametric
d. ________ 20 mm - Fixed
e. ________ 20 mm - PHS
f. ________ 20 mm - TSU
g. ________ 20 mm - GHS
h. ________ Rockets - Gunner (Pilot Override)
i. ________ TOW - Gunner
j. ________ Maneuvering into TOW Pre-Launch Constraints
k. ________ Maintaining TOW Post-Launch Constraints
l. ________ Firing Position Operations
m. ________ Terrain Flight Firing Techniques
n. ________ Doppler Navigation
o. ________ Emergency Maneuvers to Touchdown
p. ________ Contact Tasks
q. ________ Instrument Tasks

39. Use the following scale to rate the effectiveness of the **AH-1 Flight and Weapons Simulator** for training each of the task categories listed below. Fill in the blank beside each task with the appropriate whole number between 1 and 9.

1	2	3	4	5	6	7	8	9
Not at all Effective		**Slightly Effective**		**Moderately Effective**		**Highly Effective**		**Extremely Effective**

a. ________ Contact Tasks
b. ________ Instrument Tasks
c. ________ NOE Flight
d. ________ Night Goggles
e. ________ Emergency Maneuvers to Touchdowns (Autorotations, etc.)
f. ________ Gunnery
g. ________ Tactics
h. ________ Doppler Navigation

40. How many semiannual flight hours do you believe **you** would need to maintain proficiency in the gunner's crew station?
a. ________ AH-1 flight hours
b. ________ AH-1 FWS hours

41. How many semiannual flight hours do you believe **you** would need to maintain proficiency in the pilot's crew station?
a. ________ AH-1 flight hours
b. ________ AH-1 FWS hours

APPENDIX C

POSTFLIGHT DEBRIEFING

POSTFLIGHT DEBRIEFING

AH1FWS POST FIELDING TRAINING EFFECTIVENESS ANALYSIS

The following questions refer to the flight that you have just completed and should be answered as soon after the flight as possible. Read each item carefully and answer by checking [√] the appropriate box or by writing in the space provided. Respond to all questions. Regardless of the crew station you occupied, you are to complete one of these forms each time you fly in an AH-1 aircraft or the Flight and Weapons Simulator (FWS).

---

1. What is **your** full name and rank?

   ____

2. To which unit are you assigned? Fill in the blank and circle the appropriate unit designation.

   ________ = Company/Troop
   ________ = Battalion/Squadron
   ________ = Brigade/Regiment
   ________ = Division

3. Which crew station **did you occupy** during this flight?

   1[ ] Pilot
   2[ ] Gunner

4. Were **you** the PC for this flight?

   1[ ] Yes
   2[ ] No

5. What is the full name and rank of the **other crewmember** on this flight?

   ____

6. Indicate the highest **AH-1** crew duty held by the **other crewmember** on this flight:

   1[ ] Pilot
   2[ ] Pilot in Command
   3[ ] Unit Trainer
   4[ ] Instructor Pilot
   5[ ] Standardization Pilot
   6[ ] Instrument Examiner

7. How many **flight hours** does the **other crewmember** have in the **AH-1**?

   ________ AH-1 flight hours

8. What was the date of this flight?________________________________

9. What was the **primary** mission of this flight? [check one]
   1[ ] Satisfy requirements of individual aircrew training program
   2[ ] Satisfy requirements of crew training program
   3[ ] Battle drill
   4[ ] Border mission
   5[ ] Checkride (specify type)________________________________
   6[ ] Other (specify)________________________________

10. Did more than one aircraft fly on this mission?
    1[ ] Yes
    2[ ] No
    If yes,
    a. How many OH-58s? ________
    b. How many AH-1s? ________

11. How much flight time did you log on this flight under each **flight condition**?

Day	________	hours	Day Goggles	________	hours
Hood	________	hours	Night Goggles	________	hours
Night	________	hours	Weather	________	hours
Terrain	________	hours			

12. During this flight, how much flight time did you spend in the following **flight modes**:

a. Contact	________	hours	f. Low-Level	________	hours
b. Tactics	________	hours	g. Contour	________	hours
c. Gunnery	________	hours	h. Formation	________	hours
d. NOE	________	hours	i. Admin.	________	hours
e. Other (specify)________________				________	hours

13. During this flight, did you receive target handovers from another aircraft?

1[ ] Yes

2[ ] No

If yes, how many? __________ target handovers

14. During this flight, did you fire any **live ammunition**?

1[ ] Yes

2[ ] No

If yes, what kind (check all that were fired)

[ ] 20 mm

[ ] rockets

[ ] TOW

15. Was this flight in the AH-1 aircraft or the FWS?

1[ ] AH-1 aircraft

2[ ] AH-1 FWS

16. In the following table, document the number of times that you practiced specific gunnery tasks on this flight. In the row for each gunnery task that you practiced, enter the **number of times** you employed each (a) method of target acquisition, (b) method of range determination, and (c) firing technique. **Include the tasks practiced by either crewmember on this flight**, not just yourself. If neither crewmember practiced a specific task, enter zero across the row so that each block contains a response. This table must be completed **every time you fly** in the AH-1 or FWS.

FIRING MODE	ACQUISITION MODE			RANGE METHOD			FIRING TECHNIQUE		
	GHS to TSU	PHS to TSU	TSU Only	LASER	Estimate	Hand-over	Hover	Running	Diving
TOW Stationary									
TOW Moving									
Rockets Direct	X	X	X						
Rockets Indirect	X	X	X						
Rockets Stadiametric	X	X	X						
Rockets Pilot Override	X	X	X						
20 mm - Fixed	X	X	X						
20 mm - PHS	X	X	X						
20 mm - GHS	X	X	X						
20 mm - TSU									
20 mm Pilot Override									

APPENDIX D

SITUATION AND TARGET HANDOVER SHEETS FOR THE EIGHT TACTICAL SCENARIOS AND THE RANGE SCENARIO

SCENARIO 1: SITUATION

WX: AREA FORECAST: 900 OVC, 6000 M HAZE, WDS 020°/5 KTS, TEMP +11°, PA 2500, ALT 28.55.

ENEMY: Possible EW along your entire route of flight. Expect HGF from TGTs to be engaged.

MSN: Daylight deployment to delay enemy forces preventing reinforcement of EDOW from the SE.

EXECUTION:

(a) Call FARP for fuel and ammunition. Deploy from EDOW (N50°23'57", E009°55'37") to BP-1 (N50°24'20", E009°55'18"). Attack BMP with TSU GUN and deploy to BP-2 (N50°23'51", E009°53'58").

(b) From BP-2, attack tanks with TOW and deploy to BP-3 (N50°19'37", E009°50'28").

(c) From BP-3, attack SA-8 flanking BP-4 with Indirect 2.75" Rockets and deploy to BP-4 (N50°20'54", E009°49'15").

(d) From BP-4, attack BMP using 20 mm PHS and then with 20 mm GHS. From same battle position, disable SA-8 with Direct 2.75" Rockets so that running fire engagement can proceed against target located at VIC (N50°19'06", E009°47'22"). Start running fire engagement from BP-4 and engage BMP with Direct 2.75" Rockets from 2,200 meters. Complete two passes at BMP, disengage, and deploy to BP-5 (N50°23'51", E009°53'58").

(e) From BP-5, attack with TOW tanks that are moving against airfield. Then, RTB to EDOW.

WEIGHT AND BALANCE:

- See attached 365-4.
- Ammo Load = 4 TOW, 38 Rockets, and 750 20 mm.

CAL. FACTOR:

- 61.7 WITH 747 Blades.

SERVICE SUPPORT:

- Maintenance contact team, fuel, and ammo at EDOW.
- Fuel quantity on your request.

COMMAND AND SIGNAL:

- Call Sign/Freqs. per CEOI, attached.

  (a) You/Gunner = B/10, TM LDR
  (b) Scout = B/10, TM/SEC/TK3
  (c) EDOW = FARP/TOC
  (d) ALT = 124

INSTRUCTION:

- Complete all forms required for your mission and submit them to instructor/operator.

SCENARIO 1: TARGET HANDOVERS

A) BP-1 = TEP 4

TGT 9	Type	= BMP moving South
	Hdg.	= 343°
	Range	= 1,869
	Method	= 20 mm TSU

B) BP-2 = TEP 3

TGT 12	Type	= Tank Stationary
	Hdg.	= 099°
	Range	= 2,740
	Method	= TOW
TGT 10	Type	= Tank Stationary
	Hdg.	= 096°
	Range	= 2,445
	Method	= TOW

C) BP-3 = TEP 5

TGT 13	Type	= S-8 Stationary
	Hdg.	= 288°
	Range	= 3,446
	Method	= Indirect Rockets

D) BP-4 (Out of CRISP)

TGT 14	Type	= BMP Stationary
	Hdg.	= 225°
	Range	= 1,200
	Method	= 20 mm GHS
TGT 14	Type	= BMP Stationary
	Hdg.	= 225°
	Range	= 1,200
	Method	= 20 mm PHS
TGT 21	Type	= SA-8 Stationary
	Hdg.	= 210°
	Range	= 2,231
	Method	= Direct Rockets
TGT 21	Type	= BMP Stationary
	Hdg.	= 215°
	Range	= 2,200
	Method	= Running Direct Rockets

E) BP-5 = TEP 3

TGT 11	Type	=	Tank Moving South
	Hdg.	=	095°
	Range	=	2,800
	Method	=	TOW
TGT 12	Type	=	Tank Moving South
	Hdg.	=	100°
	Range	=	2,740
	Method	=	TOW

SCENARIO 2: SITUATION

WX: AREA FORECAST: 900 OVC, 6000 M HAZE, WDS 180°/5 KTS, TEMP +11°, PA 2500, ALT 28.55.

ENEMY: Possible EW along your entire route of flight. Expect HGF from TGTs to be engaged.

MSN: Dusk deployment to delay enemy forces preventing reinforcement of EDOW from the SE.

EXECUTION:

(a) Call FARP for fuel and ammunition. Deploy from CLA-5 (N50°20'05", E009°52'16") to BP-1 (N50°19'37", E009°50'28"). Attack SA-8 flanking BP-2 with Indirect 2.75" Rockets and deploy to BP-2 (N50°20'54", E009°49'15").

(b) From BP-2, attack command BMP using 20 mm PHS and then with 20 mm GHS. From same BP, disable BMP with Direct 2.75" Rockets so that running fire engagement can proceed against TGT located VIC (N50°19'06", E009°47'22"). Start running fire engagement from BP-2 and engage target with Direct 2.75" Rockets at 2,200 meters. Complete two passes at TGT, disengage, and deploy to BP-3 (N50°23'51", E009°53'58").

(c) From BP-3, attack tanks with TOW and deploy to BP-4 (N50°24'20", E009°35'18").

(d) From BP-4, attack RECON BMP with 20 mm TSU and deploy to BP-5 (N50°23'51", E009°53'58").

(e) From BP-5, engage tanks that are moving against airfield with TOW. Then, RTB to EDOW.

WEIGHT AND BALANCE:

- See attached 365-4.
- Ammo Load = 4 TOW, 38 Rockets, and 750 20 mm.

CAL. FACTOR:

- 61.7 WITH 747 Blades.

SERVICE SUPPORT:

- Maintenance contact team, fuel, and ammo at EDOW.
- Fuel quantity on your request.

COMMAND AND SIGNAL:

- Call Sign/Freqs. per CEOI Number 02.

  (a) You/Gunner = A/10, TM LDR
  (b) Scout = A/10, TM/SEC/TK3
  (c) EDOW = FARP/TOC
  (d) ALT = 127

INSTRUCTION:

- Complete all forms required for your mission and submit them to instructor/operator.

SCENARIO 2: TARGET HANDOVERS

A) BP-1 = TEP 5

TGT 13	Type	=	SA-8
	Hdg.	=	288°
	Range	=	3,446
	Method	=	Indirect Rockets

B) BP-2 (Out of CRISP)

TGT 14	Type	=	BMP
	Hdg.	=	225°
	Range	=	1,200
	Method	=	20 mm PHS
TGT 14	Type	=	BMP
	Hdg.	=	225°
	Range	=	1,200
	Method	=	20 mm GHS
TGT 21	Type	=	BMP
	Hdg.	=	210°
	Range	=	2,231
	Method	=	Direct Rockets
TGT 22	Type	=	SA-8
	Hdg.	=	215°
	Range	=	2,200
	Method	=	Direct Rockets Running Fire

C) BP-3 = TEP 3

TGT 12	Type	=	Tank
	Hdg.	=	099°
	Range	=	2,740
	Method	=	TOW
TGT 10	Type	=	Tank
	Hdg.	=	096°
	Range	=	2,445
	Method	=	TOW

D) BP-4 = TEP 4

TGT 9	Type	=	BMP
	Hdg.	=	343°
	Range	=	1,869
	Method	=	20 mm TSU

E) BP-5 = TEP 3

TGT 11	Type	=	Tank
	Hdg.	=	095°
	Range	=	2,800
	Method	=	TOW
TGT 12	Type	=	Tank
	Hdg.	=	100°
	Range	=	2,740
	Method	=	TOW

SCENARIO 3: SITUATION

WX: AREA FORECAST: 900 OVC, 6000 M HAZE, WDS 330°/5 KTS, TEMP +11°, PA 2500, ALT 28.55.

ENEMY: Possible EW along your entire route of flight. Expect HGF from TGTs to be engaged.

MSN: Dusk deployment to delay enemy forces preventing reinforcement of EDOW from the SE.

EXECUTION:

(a) Call FARP for fuel and ammunition. Takeoff from EDOW will be with fuel and ammunition required for the mission. Deploy from EDOW (N50°23'57", E009°55'37") to BP-1 at Prospect Point (N50°20'07", E009°49'49"). Attack command BMP with TOW, then destroy SA-8 flanking your position with Direct 2.75" Rockets. From BP-1, conduct running fire engagement with Direct 2.75" Rockets against ZSU-4 located in VIC N50°18'36", E009°47'06". Engage approximately 2,500 meters from TGT; make two passes; deploy to BP-2 (N50°23'18", E009°53'28").

(b) From BP-2, engage RECCE ELM T-64 Tank with TOW. Then with Indirect 2.75" Rockets, destroy one SA-9 so that you can conduct a 20 mm close-in attack from BP-3. After Indirect 2.75" Rockets, deploy to BP-3 (N50°24'47", E009°53'51").

(c) From BP-3, neutralize BRDMs within 700 meters of your position by using GHS, then hand off to PHS. After HSS engagement, use 20 mm TSU to destroy trucks to the NE of BP-3. Then, destroy tank approaching airfield from SE with TOW. Then, RTB to EDOW.

WEIGHT AND BALANCE:

- See attached 365-4.
- Ammo Load = 4 TOW, 38 Rockets, and 300 20 mm.

CAL. FACTOR:

- 61.7 WITH 747 Blades.

SERVICE SUPPORT:

- Maintenance contact team, fuel, and ammo at EDOW.
- Fuel quantity on your request.

COMMAND AND SIGNAL:

- Call Sign/Freqs. per CEOI Number 03.

(a) You/Gunner = B/10, TM LDR
(b) Scout = B/10, TM/SEC/TK3
(c) EDOW = FARP/TOC
(d) ALT = 131

INSTRUCTION:

- Complete all forms required for your mission and submit them to instructor/operator.

SCENARIO 3: TARGET HANDOVERS

A) BP-1

TGT 22	Type	=	BMP Stationary
	Hdg.	=	235°
	Range	=	3,600
	Method	=	TOW
TGT 13	Type	=	SA-8 Stationary
	Hdg.	=	272°
	Range	=	2,500
	Method	=	Direct Rockets
TGT 26	Type	=	ZSU-4 Stationary
	Hdg.	=	230°
	Range	=	2,500
	Method	=	Running Direct Rockets

B) BP-2

TGT 10	Type	=	Tank Stationary
	Hdg.	=	077°
	Range	=	3,200
	Method	=	TOW
TGT 6	Type	=	SA-9 Stationary
	Hdg.	=	025°
	Range	=	4,157
	Method	=	Indirect Rockets
	Alt.	=	250 - 300 AGL

C) BP-3

TGT 2	Type	=	BRDMs Moving East
	Hdg.	=	360°
	Range	=	650
	Method	=	20 mm GHS
TGT 3	Type	=	BRDMs Moving East
	Hdg.	=	360°
	Range	=	600
	Method	=	20 mm PHS
TGT 5	Type	=	Trucks Moving South
	Hdg.	=	050°
	Range	=	1,351
	Method	=	20 mm TSU

TGT 11	Type	=	Tank Stationary
	Hdg.	=	125°
	Range	=	3,450
	Method	=	TOW

SCENARIO 4: SITUATION

WX: AREA FORECAST: 900 OVC, 6000 M HAZE, WDS 280°/5 KTS, TEMP +11°, PA 2500, ALT 28.55.

ENEMY: Possible EW along your entire route of flight. Expect HGF from TGTs to be engaged.

MSN: Daylight deployment to delay enemy forces preventing reinforcement of EDOW from the SE.

EXECUTION:

(a) Deploy from EDOW (N50°23'57", E009°55'37") to BP-1 (N50°24'47", E009°53'51"). Attack BRDMs within 700 meters of your position by using GHS first, then PHS. After HSS engagement, use 20 mm TSU to destroy trucks to the NE of BP-1. Then, neutralize RECCE Tank approaching airfield from the SE. Deploy to BP-2 (N50°23'18", E009°53'28").

(b) From BP-2, engage tank with TOW, then destroy one SA-9 with Indirect 2.75" Rockets so that JAAT can proceed near BP-1. Then, deploy to BP-3 (N50°20'07", E009°49'49").

(c) From BP-3, attack command BMP with TOW. Then, attack SA-8 using Direct 2.75" Rockets in order to have a clear engagement for running fire. Conduct running fire with Direct 2.75" Rockets against ZSU 23-4 located in VIC N50°18'36", E009°47'06". Engagement approximately 2,500 meters from TGT. Make two passes, then RTB to EDOW.

WEIGHT AND BALANCE:

- See attached 365-4.
- Ammo Load = 4 TOW, 38 Rockets, and 300 20 mm.

CAL. FACTOR:

- 61.7 WITH 747 Blades.

SERVICE SUPPORT:

- Maintenance contact team, fuel, and ammo at EDOW.
- Fuel quantity on your request.

COMMAND AND SIGNAL:

- Call Sign/Freqs. per CEOI Number 04.

  (a) You/Gunner = B/10, TM LDR
  (b) Scout = B/10, TM/SEC/TK3
  (c) EDOW = FARP/TOC
  (d) ALT = 128

INSTRUCTION:

- Complete all forms required for your mission and submit them to instructor/operator.

SCENARIO 4: TARGET HANDOVERS

A) BP-1

TGT 2	Type	=	BRDMs
	Hdg.	=	360°
	Range	=	650
	Method	=	20 mm GHS
TGT 3	Type	=	BRDMs
	Hdg.	=	360°
	Range	=	600
	Method	=	20 mm PHS
TGT 5	Type	=	Trucks
	Hdg.	=	050°
	Range	=	1,351
	Method	=	20 mm TSU
TGT 11	Type	=	Tank
	Hdg.	=	125°
	Range	=	3,450
	Method	=	TOW

B) BP-2

TGT 10	Type	=	Tank
	Hdg.	=	077°
	Range	=	3,200
	Method	=	TOW
TGT 6	Type	=	SA-9
	Hdg.	=	025°
	Range	=	4,157
	Method	=	Indirect Rockets

C) BP-3

TGT 22	Type	=	BMP
	Hdg.	=	235°
	Range	=	3,600
	Method	=	TOW
TGT 13	Type	=	SA-8
	Hdg.	=	272°
	Range	=	2,500
	Method	=	Direct Rockets

TGT 26	Type	=	ZSU-4
Running	Hdg.	=	230°
	Range	=	2,500
	Method	=	Running Direct Rockets

SCENARIO 5: SITUATION

WX: AREA FORECAST: 900 OVC, 6000 M HAZE, WDS 090°/5 KTS, TEMP +11°, PA 2500, ALT 28.55.

ENEMY: Possible EW along your entire route of flight. Expect HGF from TGTs to be engaged.

MSN: Dusk deployment from EDOW (N50°23'57", E009°55'37") to FARP (N50°23'18", E009°53'28"). On arrival, contact S-3 for ammo up load and fuel. Deploy to BP-4 (N50°24'20", E009°55'18").

EXECUTION:

(a) From BP-4, attack BMP with 20 mm and deploy to BP-6 (N50°18'40", E009°50'21").

(b) From BP-6, attack tank with TOW and deploy to BP-5 (N50°19'37", E009°50'28").

(c) From BP-5, attack SA-8 with 2.75" Rockets and deploy to FARP.

WEIGHT AND BALANCE:

- See attached 365-4.
- Ammo Load = 4 TOW, 38 Rockets, and 750 20 mm.

CAL. FACTOR:

- 61.7 WITH 747 Blades.

SERVICE SUPPORT:

- Maintenance contact team, fuel, and ammo at EDOW.
- Fuel quantity on your request.

COMMAND AND SIGNAL:

- Call Sign/Freqs. per CEOI Number 05.

(a) You/Gunner = ATK/B/10, TM LDR
(b) Scout = SCT/B/10, TM/SEC/TK1
(c) EDOW = FARP/TOC
(d) ALT = 122

INSTRUCTION:

- Complete all forms required for your mission and submit them to instructor/operator.

SCENARIO 5: TARGET HANDOVERS

A) BP-4 = TEP 4

TGT 9	Type	=	BMP Moving
	Hdg.	=	343°
	Range	=	1,869
	Method	=	20 mm TSU

B) BP-6 = TEP 6

TGT 21	Type	=	Tank
	Hdg.	=	310°
	Range	=	3,100
	Method	=	TOW

C) BP-5 = TEP 5

TGT 13	Type	=	SA-8
	Hdg.	=	288°
	Range	=	3,446
	Method	=	Indirect Rockets

SCENARIO 6: SITUATION

WX: AREA FORECAST: 900 OVC, 6000 M HAZE, WDS 250°/5 KTS, TEMP +11°, PA 2500, ALT 28.55.

ENEMY: Possible EW along your entire route of flight. Expect HGF from TGTs to be engaged.

MSN: Dusk deployment to delay enemy forces preventing reinforcement of EDOW from the SE.

EXECUTION:

(a) Deploy from CLA-2 (N50°19'04", E009°48'37") to BP-6 (N50°18'40", E009°50'21"). Attack tank with TOW and deploy to BP-5 (N50°19'37", E009°50'28").

(b) From BP-5, attack an SA-8 with 2.75" Rockets and deploy to BP-4 (N50°24'20", E009°55'18").

(c) From BP-4, attack BMP with 20 mm and RTB to EDOW (N50°28'57", E009°55'37").

WEIGHT AND BALANCE:

- See attached 365-4.
- Ammo Load = 4 TOW, 38 Rockets, and 750 20 mm.

CAL. FACTOR:

- 61.7 With 747 Blades.

SERVICE SUPPORT:

- Maintenance contact team, fuel, and ammo at EDOW.
- Fuel quantity on your request.

COMMAND AND SIGNAL:

- Call Sign/Freqs. per CEOI Number 06.

(a) You/Gunner = B/10, TM LDR
(b) Scout = B/10, TM/SEC/TK3
(c) EDOW = FARP/TOC
(d) ALT = 135

INSTRUCTION:

- Complete all forms required for your mission and submit them to instructor/operator.

SCENARIO 6: TARGET HANDOVERS

A) BP-6 = TEP 6

TGT 21	Type	=	Tank Moving South
	Hdg.	=	310°
	Range	=	3,100
	Method	=	TOW

B) BP-5 = TEP 5

TGT 13	Type	=	SA-8
	Hdg.	=	288°
	Range	=	3,446
	Method	=	Indirect Rockets

C) BP-4 = TEP 4

TGT 9	Type	=	BMP
	Hdg.	=	343°
	Range	=	1,896
	Method	=	20 mm TSU

SCENARIO 7: SITUATION

WX: AREA FORECAST: 900 OVC, 6000 M HAZE, WDS 020°/5 KTS, TEMP +11°, PA 2500, ALT 28.55.

ENEMY: Possible EW along your entire route of flight. Expect HGF from TGTs to be engaged.

MSN: Daylight deployment to delay enemy forces preventing reinforcement of EDOW from the SW.

EXECUTION:

(a) Call FARP for fuel and ammunition. Deploy from EDOW (N50°23'57", E009°55'37") to BP-1 (N50°20'52", E009°49'18"). Attack BRDM with 20 mm PHS and handoff to gunner for 20 mm GHS. Then engage SA-8 with TOW and deploy to BP-2 (N50°19'56", E009°49'32").

(b) From BP-2, engage BMP with 20 mm TSU Running Fire and deploy to BP-3 (N50°19'12", E009°48'35").

(c) From BP-3, develop combined 20 mm and Direct Rocket attack against MTU-20 Track Launched Bridge and BRDM. Then, RTB to EDOW.

WEIGHT AND BALANCE:

- See attached 365-4.
- Ammo Load = 4 TOW, 38 Rockets, and 750 20 mm.

CAL. FACTOR:

- 61.7 With 747 Blades.

SERVICE SUPPORT:

- Maintenance contact team, fuel, and ammo at EDOW.
- Fuel quantity on your request.

COMMAND AND SIGNAL:

- Call Sign/Freqs. per CEOI, attached

(a) You/Gunner = B/10, TM LDR
(b) Scout = B/10, TM/SEC/TK3
(c) EDOW = FARP/TOC

INSTRUCTION:

- Complete all forms required for your mission and submit them to instructor/operator.

SCENARIO 7: TARGET HANDOVERS

A) BP-1

TGT 14	Type	=	BRDM
	Hdg.	=	230°
	Range	=	1,100
	Method	=	20 mm PHS
TGT 14	Type	=	BRDM
	Hdg.	=	230°
	Range	=	1,100
	Method	=	20 mm GHS
TGT 13	Type	=	SA-8
	Hdg.	=	230°
	Range	=	2,450
	Method	=	TOW

B) BP-2

TGT 15	Type	=	BMP
	Hdg.	=	310°
	Range	=	1,400
	Method	=	20 mm TSU Running Fire

C) BP-3

TGT 14	Type	=	BRDM Stationary
	Hdg.	=	360°
	Range	=	2,100
	Method	=	Direct Rockets
BRIDGE	Type	=	MTU-20 Tk. Launched Bridge
	Hdg.	=	010°
	Range	=	600
	Method	=	20 mm

SCENARIO 8: SITUATION

WX: AREA FORECAST: 900 OVC, 6000 M HAZE, WDS 020°/5 KTS, TEMP +11°, PA 2500, ALT 28.55.

ENEMY: Possible EW along your entire route of flight. Expect HGF from TGTs to be engaged.

MSN: Daylight deployment in order to delay enemy forces preventing reinforcement of EDOW from the SE.

EXECUTION:

(a) Call FARP for fuel and ammunition. From CLA-2 (N50°19'04", E009°48'37") deploy to BP-1 (N50°19'12", E009°48'35"). Develop combined 20 mm and Direct Rocket attack against BMP at approximately 1,500 meters and BRDM at approximately 2,400 meters. Then deploy to BP-2 (N50°19'56", E009°49'32").

(b) From BP-2, engage BMP with 20 mm TSU Running Fire and deploy to BP-3 (N50°20'52", E009°49'18").

(c) From BP-3, attack BRDM with 20 mm PHS and handoff to 20 mm GHS for reattack. Then, engage SA-8 with TOW and deploy to EDOW (N50°23'57", E009°55'37").

WEIGHT AND BALANCE:

- See attached 365-4.
- Ammo Load = 4 TOW, 38 Rockets, and 750 20 mm.

CAL. FACTOR:

- 61.7 With 747 Blades.

SERVICE SUPPORT:

- Maintenance contact team, fuel, and ammo at EDOW.
- Fuel quantity on your request.

COMMAND AND SIGNAL:

- Call Sign/Freqs. per CEOI, attached

(a) You/Gunner = B/10, TM LDR
(b) Scout = B/10, TM/SEC/TK3
(c) EDOW = FARP/TOC
(d) ALT = 124

INSTRUCTION:

- Complete all forms required for your mission and submit them to instructor/operator.

SCENARIO 8: TARGET HANDOVERS

A) BP-1

TGT 18	Type	=	BMP
	Hdg.	=	350°
	Range	=	1,500
	Method	=	20 mm
TGT 15	Type	=	BRDM
	Hdg.	=	350°
	Range	=	2,400
	Method	=	Direct Rockets

B) BP-2

TGT 15	Type	=	BMP
	Hdg.	=	310°
	Range	=	1,400
	Method	=	20 mm TSU Running Fire

C) BP-3

TGT 14	Type	=	BRDM
	Hdg.	=	230°
	Range	=	1,100
	Method	=	20 mm PHS
TGT 14	Type	=	BRDM
	Hdg.	=	230°
	Range	=	1,100
	Method	=	20 mm GHS
TGT 13	Type	=	SA-8
	Hdg.	=	230°
	Range	=	2,450
	Method	=	TOW

RANGE SCENARIO: SITUATION

WX: AREA FORECAST: 900 OVC, 6000 M HAZE, WDS 180°/5 KTS, TEMP +11°, PA 2500, ALT 28.55.

MSN: Daylight deployment. This mission approximates Gunnery Table VIII. Direct flights between BPs may be conducted without opposition. Within BPs, tactics should be consistent with the presence of threat forces.

EXECUTION:

(a) Call FARP for fuel and ammunition. Deploy from CLA-2 (NA 576587436) to BP-1 (NA 55677384).

(b) Attack a BMP with Indirect 2.75 Rockets. Deploy to BP-2 (NA 58657783).

(c) Attack a BMP with 20 mm TSU. Return to BP-1.

(d) In a combined engagement, attack a BMP with 20 mm GHS and a second BMP with Direct Rockets. In a second combined engagement, attack a BMP with 20 mm TSU and an SA-8 with Direct Rockets. Deploy to BP-8 (NA 55077222).

(e) In a combined engagement, attack a ZSU with 20 mm TSU and a BMP with Direct Rockets. Deploy to BP-3 (NA 56177440).

(f) From BP-3, attack a BMP with 20 mm PHS. Deploy to BP-5 (NA 59877543).

(g) From BP-5, attack a tank with TOW missile. RTB.

WEIGHT AND BALANCE:

- Ammo Load = 38 Rockets, 750 rds 20 mm, 4 TOW.

CAL. FACTOR:

- 61.7 WITH 747 Blades.

SERVICE SUPPORT:

- Maintenance, fuel, and ammo at CLA-2.
- Fuel quantity on your request.

COMMAND AND SIGNAL:

- Call Sign/Freqs. per CEOI Number 3, attached.

(a) You/Gunner = B/10, TM LDR
(b) Scout = B/10, TM/SEC/TK3
(c) EDOW = FARP/TOC
(d) ALT = 131

INSTRUCTION:

- Complete all forms required for your mission and submit them to instructor/operator.

RANGE SCENARIO: TARGET HANDOVERS

A) BP-1

TGT 14	Type	=	BMP
	Hdg.	=	030°
	Range	=	3,600
	Method	=	Indirect Rockets

B) BP-2

TGT 14	Type	=	BMP
	Hdg.	=	230°
	Range	=	1,100
	Method	=	20 mm TSU

C) BP-1 (Combined Engagement - Handover Together)

TGT 22	Type	=	BMP
	Hdg.	=	045°
	Range	=	600
	Method	=	20 mm GHS
TGT 14	Type	=	BMP
	Hdg.	=	030°
	Range	=	3,600
	Method	=	Direct Rockets

D) BP-1 (Same BP; Combined Engagement - Handover Together)

TGT 22	Type	=	BMP
	Hdg.	=	045°
	Range	=	600
	Method	=	20 mm TSU
TGT 21	Type	=	SA-8
	Hdg.	=	030°
	Range	=	2,200
	Method	=	Direct Rockets

E) BP-8 = TEP 8 (Combined Engagement - Handover Together)

TGT 25	Type	=	ZSU
	Hdg.	=	035°
	Range	=	1,500
	Method	=	20 mm TSU
TGT 22	Type	=	BMP
	Hdg.	=	035°
	Range	=	2,200
	Method	=	Direct Rockets

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