

Technical Report 920

AD-A233 198

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# Transfer of SIMNET Training in the Armor Officer Basic Course

David W. Bessemer  
U.S. Army Research Institute

January 1991

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## REPORT DOCUMENTATION PAGE

Form Approved  
OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION Unclassified		1b. RESTRICTIVE MARKINGS ---	
2a. SECURITY CLASSIFICATION AUTHORITY ---		3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; distribution is unlimited.	
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE ---		4. PERFORMING ORGANIZATION REPORT NUMBER(S)  ARI Technical Report 920	
5. MONITORING ORGANIZATION REPORT NUMBER(S) ---		6a. NAME OF PERFORMING ORGANIZATION U.S. Army Research Institute Field Unit at Fort Knox, KY	
6b. OFFICE SYMBOL (if applicable) PERI-IK		7a. NAME OF MONITORING ORGANIZATION	
6c. ADDRESS (City, State, and ZIP Code)  Fort Knox, KY 40121-5620		7b. ADDRESS (City, State, and ZIP Code)	
8a. NAME OF FUNDING/SPONSORING ORGANIZATION U.S. Army Research Institute for the Behavioral and Social Sciences		8b. OFFICE SYMBOL (if applicable) PERI-I	
8c. ADDRESS (City, State, and ZIP Code)  5001 Eisenhower Avenue Alexandria, VA 22333-5600		9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER ---	
10. SOURCE OF FUNDING NUMBERS		11. TITLE (Include Security Classification)	
PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT ACCESSION NO.
63744A	795	3204	H2
Transfer of SIMNET Training in the Armor Officer Basic Course			
12. PERSONAL AUTHOR(S) Bessemer, David W.			
13a. TYPE OF REPORT Interim	13b. TIME COVERED FROM 88/10 TO 90/09	14. DATE OF REPORT (Year, Month, Day) 1991, January	15. PAGE COUNT
16. SUPPLEMENTARY NOTATION			
17. COSATI CODES		18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)	
FIELD	GROUP	SUB-GROUP	
			Armor training
			Leader training
			Training devices
			Collective training
			Networked simulation
			Simulator networks
19. ABSTRACT (Continue on reverse if necessary and identify by block number)			
<p>Tactical training using networked tank simulators in the Armor Officer Basic Course allowed a quasi-experimental assessment of transfer to student officer performance in field training. Baseline classes without simulator training were compared in an interrupted time-series design to classes with simulator training. Regression analyses were performed on measures obtained from course records. Transfer of training was found using indicators of (a) the amount and type of field training conducted, (b) officer performance in leadership positions within student platoons, and (c) overall tactical leadership qualities shown by students as rated just prior to course graduation. Benefits of simulator training increased progressively in successive classes as the instructors "learned to train" using the simulators. The "learning to train" factor may often cause underestimation of the value of training devices. The report discusses implications for testing and evaluating military training innovations.</p>			
20. DISTRIBUTION/AVAILABILITY OF ABSTRACT <input checked="" type="checkbox"/> UNCLASSIFIED/UNLIMITED <input type="checkbox"/> SAME AS RPT. <input type="checkbox"/> DTIC USERS		21. ABSTRACT SECURITY CLASSIFICATION Unclassified	
22a. NAME OF RESPONSIBLE INDIVIDUAL Bessemer, David W.		22b. TELEPHONE (Include Area Code) (502) 624-2613	22c. OFFICE SYMBOL PERI-IK

**Technical Report 920**

**Transfer of SIMNET Training in the  
Armor Officer Basic Course**

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**January 1991**

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**Army Project Number**  
**2Q263744A795**

**Training and Simulation**

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## FOREWORD

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The U.S. Army Research Institute for the Behavioral and Social Sciences (ARI) Field Unit at Fort Knox is responsible for conducting research in Armor training and simulation and in human performance in Armor weapon systems. This research investigated tactical training for officers using the simulator networking (SIMNET) system located in the Combined Arms Tactical Training Center (CATTTC) at Fort Knox. The research capitalized on a unique opportunity to examine transfer of tactical training to leader performance in platoon-level field exercises. This opportunity arose when SIMNET and other training was added to the Armor Officer Basic (AOB) Course taught by the Command and Staff Department in the Armor School. Based on course records and observations of SIMNET training, this report identifies changes in field training, student performance, and the quality of tactical leadership exhibited by AOB graduates that primarily are the result of SIMNET training.

This research was initiated at the request of the Commanding General, U.S. Army Armor Center (USAARMC), and Fort Knox, pursuant to a Letter of Agreement (LOA) between ARI, USAARMC, the U.S. Army Materiel Command, and the U.S. Army Training and Doctrine Command, effective 16 January 1989. The LOA, entitled "Effects of Simulators and Other Training Resources on Training Readiness," identified needs for research on leader and unit training methods for networked simulators.

The findings of this research were briefed to the Armor School Deputy Assistant Commandant, the Director of Training and Doctrine, the Director of the Command and Staff Department, and the Chief, Combined Arms Tactical Training Center. The results offer proof of concept for training methods in networked simulators, and will affect Army decisions on requirements and research and development for future networked simulators. The report also should be of interest to agencies responsible for testing and evaluating the effectiveness of training devices and simulators.



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## ACKNOWLEDGMENTS

The author is indebted to several U.S. Army Research Institute for the Behavioral and Social Sciences staff members who contributed to this research. The ARI Field Unit R&D Coordinator, Major Milton E. Koger, arranged access to Armor School student records that were indispensable for this research. Dr. Theodore M. Schlecter contributed important insights derived from his observations of training in SIMNET. Catherine Rangel, Pamela Mattingly, and Marc Dowell deserve special recognition for diligence and accuracy when compiling data and preparing computer files for analysis.

<b>Accession For</b>	
NTIS GRA&I	<input checked="" type="checkbox"/>
DTIC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	
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Distribution/	
<b>Availability Codes</b>	
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# TRANSFER OF SIMNET TRAINING IN THE ARMOR OFFICER BASIC COURSE

## EXECUTIVE SUMMARY

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### Requirement:

This research examined the effects of tactical training exercises added to the Armor Officer Basic (AOB) Course. The additional exercises included training conducted in a simulator networking (SIMNET) system and field training with high mobility multipurpose wheeled vehicles (HMMWVs) substituted for tanks. The primary purpose was to assess the results of SIMNET training for officers in a school setting, complementary to results of other Army tests that use intact units. This research was initiated at the request of the Commanding General, U.S. Army Armor Center and Fort Knox.

### Procedure:

A quasi-experimental comparison was made between AOB classes before and after the course was expanded to add SIMNET training. The research method was based on analysis of data forming an interrupted time series, i.e., a sequence of measures associated with conditions changed at a specific point in time. Dependent variables were derived from class records of instructor ratings for AOB students in field exercises during Mounted Tactical Training (MTT) and after MTT just before graduation. Selected data on the rating forms were used to measure (a) the amount and type of training conducted in MTT, (b) tactical performance of students acting in leader positions within student platoons in MTT, (c) the final quality of AOB graduates in tactical leadership, and (d) student background characteristics. The average values and time-dependent trends for these variables were examined in regression analyses to detect changes in student learning and performance attributable to the effects of SIMNET.

### Findings:

Additional tactical training in the AOB Course produced positive transfer of training in the MTT and indications that the transfer effect persisted to enhance the quality of AOB graduates, at least in the later classes given the extra training. Both the SIMNET and HMMWV training appeared to contribute to a reduction by the instructors of the number of elementary contact

exercises required in the MTT. This savings occurred soon after the added training was introduced. The preponderance of evidence indicated that transfer to student performance in the MTT exercises increased gradually in the successive AOB classes that had additional training. As MTT performance increased, the instructors progressively added to the number of advanced exercises involving defensive and offensive missions that were completed in the MTT. The judged quality of AOB graduates in tactical leadership increased with the increases in performance and the amount of advanced training. Observations also suggested that SIMNET training became more effective as the AOB instructors gained experience training students in that environment. Gains in MTT performance, in the amount of advanced training, and in graduate quality can be attributed to improved SIMNET training, rather than the HMMWV training.

#### Utilization of Findings:

The results contribute to proof of concept for training methods used with networked simulators, and will assist Army decisions on requirements for future networked simulators, in particular, the Close Combat Tactical Trainer (CCTT). The research methodology also has wide applicability to training innovations, and should be of interest to Army agencies responsible for testing and evaluating the effectiveness of training devices and simulators.

# TRANSFER OF SIMNET TRAINING IN THE ARMOR OFFICER BASIC COURSE

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# TRANSFER OF SIMNET TRAINING IN THE ARMOR OFFICER BASIC COURSE

## Introduction

Late in 1988, the Armor School began to train students in the Armor Officer Basic (AOB) Course using tank simulators that are connected together by a local area computer network. Added maneuver training using wheeled vehicles to simulate tanks was instituted at nearly the same time. This report presents research conducted to determine how the AOB students profited from the additional training.

Simulated tactical exercises were added following classroom training to prepare the students better for the intensive Mounted Tactical Training (MTT) that concludes the course. In the MTT, students remain in the field continuously for a ten-day period training to serve in the role of platoon leader. They plan and execute basic platoon combat missions in a series of field exercises that increase in difficulty. Organized as crews and platoons, the students rotate among the leader positions to perform under a variety of conditions all the important tactical techniques learned earlier in the classroom.

The installation of simulator training in the course sequence prior to the MTT provided an unusual opportunity to examine transfer of simulator training by means of effects on student performance during the MTT exercises. The AOB Course was particularly useful for this purpose since records were available for students in classes before simulator training was introduced. This provided a baseline of MTT performance for discovery of transfer effects in later classes. Furthermore, the number of classes before and after the change in training was substantial. With large student samples for comparison, even small changes resulting from simulator training could be detected reliably.

The Simulator Networking (SIMNET) system used in the AOB training was produced in Defense Advanced Research Projects Agency (DARPA) research and development on technologies enabling large-scale interactive simulation of land combat. The SIMNET system provides a test bed to investigate whether combat leaders and units can practice critical collective skills effectively in a simulated environment. Effective combat training in simulators is needed to help overcome current limitations on combined arms field exercises that are imposed by costs of fuel and vehicle maintenance, availability of maneuver areas, and safety considerations.

When fully developed and implemented, networked simulators are expected to support a major share of combat unit training in the U.S. Army. The current concept for such a system, known as the Close Combat Tactical Trainer (CCTT), is nearing approval as a device requirement and will soon enter the research and development process leading to procurement.

## Background

Although SIMNET has been in operation for a relatively short time, two projects have been completed to assess the training effectiveness of the system for unit gunnery and tactics. Both projects were intended to gather objective findings that help to refine Army requirements for future networked simulators, in particular, the CCTT.

Kraemer and Bessemer (1987) examined platoon gunnery training in three U.S. Army Europe (USAREUR) tank companies that were preparing for the Canadian Army Trophy competition. SIMNET tank simulators are not specifically designed as gunnery trainers and do not completely and accurately represent all elements of precision gunnery. However, the USAREUR units used SIMNET to practice fire coordination in platoon battle runs with a simulated range portraying the conditions of the competition range. While no control group was available for comparison, three platoons scored high in the competition, and the remaining six were near or above average. The platoon scores showed a modest relationship to the amount of training in SIMNET.

Observations of the units during their training indicated that the SIMNET practice in some instances helped the platoons to develop and improve fire control plans, and helped the platoon leaders to acquire command, control, and communication (C<sup>3</sup>) skills contributing to proficient execution of their plans. Many factors seemed to be important determinants of the results. One interesting effect was that the training method used by the instructor, especially the effort devoted to detailed after-action reviews of the practice runs, seemed to have a major influence on the value of SIMNET training.

A Concept Evaluation Program (CEP) test on tactical training in SIMNET (Gound & Schwab, 1988) was performed with eight tank platoons drawn from four companies. The platoons were pretested in three situational training exercises (STXs) based on the coordinating draft of the tank platoon Mission Training Plans (ARTEP 17-237-10-MTP, U.S. Department of the Army, 1988a). Tanks were fitted with Multiple Integrated Laser Engagement Simulation (MILES) equipment during the STXs. The pretest STXs required the platoons to execute movement to contact, hasty attack, and hasty defense missions. Following the pretest, four platoons were transported to Fort Knox for six days of training in SIMNET. The other four platoons remained at their home station to complete six days of similar field training without MILES equipment. In both cases, the platoons practiced task prerequisites for the STXs, and repeated similar STXs with different terrain. All platoons were then retested in the same STXs performed in the pretest, but using different terrain.

Performance improved substantially from pretest to posttest for two of the platoons in the SIMNET group. One platoon in the field-trained group similarly improved, and the performance of

one platoon decreased. The interpretation of the results was complicated by the fact that the SIMNET-trained platoons were better on the pretest than those trained in the field. The SIMNET group correctly performed more tasks in the posttest, but the difference was not statistically significant for these small samples. Gains from pretest to posttest were not compared statistically, but the field-trained group showed little average gain. Based on these results and other supporting data from questionnaires, the main conclusion was that SIMNET was useful in training planning, troop leading procedures, command and control, land navigation, reporting procedures, maneuver techniques, and teamwork in crews and platoon. The importance of AARs in the SIMNET training was also pointed out by the CEP observers.

A preliminary training developments study (PTDS) report (Brown, Pishel, & Southard, 1988) reanalyzed the CEP data together with observations on the same platoons obtained in a later company-level Army Training and Evaluation Program (ARTEP) exercise. ARTEP observations indicated that platoons trained in SIMNET communicated more, had better command and control and fire distribution, and showed better teamwork by the wingman tanks. Platoons with field training seemed to make better use of terrain for cover. The PTDS report did not materially alter the main conclusions of the CEP report.

Neither completed project examined the separate contributions of leaders and of other personnel to platoon performance. Measures of collective task performance do not specify what the officers and senior noncommissioned officers (NCOs) learned apart from what the tank crewmen learned. While there were many indications that SIMNET training increased leader performance, gains observed in aspects of platoon leadership could be partly the indirect result of better execution of orders by the followers. The independent value of SIMNET for leader training has yet to be established.

Several limitations of the simulation were noted in both the CEP and PTDS reports, and by Kraemer & Bessemer (1987). The most serious ones were (a) an ability to drive over terrain at high speeds that are unrealistic and possibly dangerous, (b) the difficulty of detecting and engaging targets at ranges more than a kilometer, (c) terrain lacking irregularities that provide hull- or turret-down defilade positions, and (d) a tank commander's station without an all-around viewing capability. Similar problems were identified in questionnaire data gathered from Army Reserve personnel trained in SIMNET (Brown & Mullis, 1988). Solutions to these problems are required for the CCTT to be more realistic.

### Purpose

The primary purpose of this project was to assess the results of SIMNET training for officers in an institutional training setting, supplementing other test results that use

intact units. A quasi-experimental comparison was made between AOB classes before and after the SIMNET training was added. Dependent variables were derived from instructor ratings on AOB students that are kept in class records.

The specific objectives were: (a) to find changes in how the MTT field training was conducted, (b) to estimate transfer from the additional tactical training to student performance as leaders in MTT field exercises, and (c) to gauge the ultimate impact of the additional training on the final evaluation of the quality of tactical leadership for AOB Course graduates. An important issue in the analysis and interpretation of the findings was whether the SIMNET training was responsible for observed effects, or other factors, such as the wheeled vehicle training, caused the changes.

## Method

### Approach

Data source. Available records were examined for students in AOB classes from mid-1987 to mid-1989. The records were in files kept by the Command and Staff Department for up to two years after graduation of each AOB class. Armor School forms on file are the (a) FIELD EVALUATION-ARMOR PLATOON TACTICS (ATSB-CS Form 1447), and the (b) COMPREHENSIVE STUDENT EVALUATION-AOB TACTICS PHASE (ATSB-CS Form 1445). The first form is used to judge the tactical performance of students in field exercises. The second form is used after completing the tactical phase of the course, just prior to graduation, to judge general tactical leadership qualities exhibited by the students.

Data derived from selected information on the forms were used to measure (a) the amount and type of training conducted in MTT, (b) student tactical performance in leader positions, and (c) the quality of AOB graduates in tactical leadership. Trends over time were analyzed before and after SIMNET training was included in the AOB Course to detect changes attributable to the effects of SIMNET on student learning and performance.

Research design. The addition of SIMNET training to the AOB Course produced a standard arrangement of conditions known as an interrupted time-series design (Campbell & Stanley, 1963; Cook & Campbell, 1979). Measurements taken from successive AOB classes over an extended time period constitute time-series that were interrupted by the change in training conditions when SIMNET began to be used. This design permits a quasi-experimental comparison between (a) baseline classes before the change that serve as a control group, and (b) SIMNET classes after the change that serve as a treatment group. The comparison is termed quasi-experimental because training conditions were not manipulated to randomly assign classes to the groups. Therefore, the time periods and any time-associated variables confound the training conditions.

In this design, effects of the SIMNET training are revealed by consistent differences in measured values found between the baseline and SIMNET groups. For example, the average level of a measure might differ between groups, or a trend over time found in the baseline group might change after SIMNET training started. However, lacking random assignment of classes to conditions, several variables can differ between groups in addition to the training conditions. A group difference of any kind may produce or modify the effects observed in the dependent measure. Then other related evidence must be marshalled to distinguish between alternative interpretations.

In addition to the change in training conditions, the evaluation forms were changed in the middle of the baseline period. This change is a second interruption to the time series, requiring a further subdivision of classes to compare the group rated with the old form to the group rated with the new form after the change. Of course, any such comparison assumes that the change in forms did not affect what was being rated, but only the quantitative relationship of the ratings to a common subjective scale.

### Sample

Records were obtained for 1705 students enrolled in 36 AOB classes between mid-1987 and mid-1989. Based on available records, the classes had one to five platoons with from 11 to 20 students per platoon, making a total of 110 platoons. Acting as Team Chiefs, 16 different officers and senior NCOs supervised these platoons in tactical training, with one platoon per Team Chief in a class. The Team Chiefs were assisted in training by several NCO Tank Crew Instructors (TCIs). A relatively senior TCI served as Assistant Team Chief. The other TCIs were assigned to train groups of three to four students who remained together as tank crews during the tactical phase of the course.

Table 1 shows the division of classes, platoons, and students among the three time segments examined. In addition to the two groups that contained baseline and SIMNET classes, the baseline groups were further divided into two subgroups evaluated with different forms (old versus new). The sample numbers were roughly proportional to the time period in each segment.

### Training Equipment

SIMNET training. AOB student platoons were trained using the SIMNET tank simulators located in the Combined Arms Tactical Training Center (CATTC) at Fort Knox. CATTC and the SIMNET system are described in Appendix A. The AOB classes used four M1 tank modules per platoon. SIMNET exercises were conducted using a terrain data base that portrays Fort Knox. The simulated terrain included areas representing Training Areas 8, 9, and 10 that are normally used for AOB field training. A SAFOR platoon

Table 1

Samples in Segments of Training Available for Analysis

Sampling Unit	Baseline		SIMNET <sup>a</sup> New Form
	Old Form	New Form <sup>b</sup>	
<b>Classes</b>			
Number	7	17	12
Percentage	19.4	47.2	33.3
<b>Platoons</b>			
Number	23	48	39
Percentage	20.9	43.6	35.5
<b>Students</b>			
Number	352	746	607
Percentage	20.7	43.8	35.6
<b>Time Period (Weeks)</b>			
Number	20	48	33
Percentage	19.8	47.5	32.7

<sup>a</sup>This group includes one Reserve Component class, consisting of one platoon and 13 students, that did not get any training in SIMNET before MTT in the field. <sup>b</sup>This group includes two Reserve Component classes, with three platoons and 38 students.

with four tanks acted in an OPFOR role to pair up with one AOB platoon in force-on-force (FOF) exercises whenever an AOB class had an odd number of platoons.

Team Chiefs used the Plan View Display (PVD) and Stealth Display (when available) in the control center to monitor platoon actions. An additional tank or infantry fighting vehicle module was activated near each platoon for optional use for this purpose by the Team Chief or Assistant Team Chief. The Team Chiefs used radios in the control center or vehicles to communicate with the Platoon Leaders in order to simulate their company commanders.

In AOB training exercises, only the fire support station and radios in the SIMNET Tactical Operations Center (TOC) were used. A senior NCO operator simulated a company Fire Support Team (FIST). The radios allowed the NCO to monitor the nets used by Platoon Leaders and Team Chiefs, and also to communicate with the Team Chiefs without being heard by the Platoon Leaders. The NCO

scheduled planned fires and responded to platoon leader calls for fire like a FIST, and also delivered simulated enemy indirect fire at locations requested by the Team Chiefs.

The Data Logger was not used in AOB training, since one PVD will not support separate replays for simultaneous AARs with different platoons, or pairs of platoons. Instead of the PVD replay, the AOB platoons used easel stands with pads as training aids during AARs. The easel pads held hand-drawn sketch maps of the terrain area used in the exercise together with the overlaid operational control measures specified in the mission orders.

Field training. Each AOB student crew in SIMNET-trained classes (except for the first such class) used High Mobility Multi-Purpose Wheeled Vehicles (HMMWVs) for some MTT-like preparatory training on cavalry operations. All student crews used an M60A3 tank (U.S. Department of the Army, 1979) and basic issue items furnished with the tank during MTT. A special chair was mounted on the turret of each tank to enable a TCI to ride with and observe the crew. Field exercises were conducted in several parts of Training Areas 8, 9, and 10 at Fort Knox. The Team Chiefs and Assistant Team Chiefs used HMMWVs to move cross-country with their platoon. Smoke grenades of various colors were used to indicate different types of enemy fire, and artillery simulators were used to represent indirect fires.

### Procedure

AOB program of instruction. The AOB course is 17-18 weeks long, with approximately the last 4 weeks devoted to tactics. Main subjects in eight days of classroom instruction are (1) Basic Armor Techniques, (2) Cavalry Operations, (3) Offensive Operations, and (4) Defensive Operations. Instruction on offense and defense is equally divided between lectures and practice on a terrain board. After a Performance Examination using the terrain board, students complete the Mounted Tactical Training (MTT), ten days of tank platoon exercises in a field environment. Appendix B describes the content of the classroom subjects in the tactical phase of the course. This appendix also summarizes the instructional sequence and schedules followed by classes that contribute data to this research.

SIMNET training added 18 hours and two days to the course sequence prior to the MTT. After the first SIMNET-trained class, HMMWV training on basic techniques and cavalry operations in the field added 30 hours and more than one day before classroom instruction resumed on offense and defense. Hours were reduced in the pre-tactics portion of the course, and in periods scheduled for the performance examination, review, and retest. This compensated for all but one day of the additional training.

SIMNET training. This training began the day after the Performance Examination. In the morning of the first day, students were given a short briefing to introduce them to SIMNET.

The TCIs then trained the members of each crew to operate each of the simulated tank crew stations in a SIMNET module. Crews then spent time maneuvering their simulated tanks on SIMNET terrain under TCI direction in order to practice driving and gunnery procedures. After this two-hour orientation period, a two-hour tactical road march exercise for all platoons filled the remainder of the morning.

Each platoon Team Chief designated students from different crews to act as platoon leader and platoon sergeant, and other students to act as tank commanders (TCs) in the road march. The Team Chief gave them an oral five-paragraph operational order (OPORD) for a company-level march. Each platoon was assigned an initial assembly area (AA) where the vehicles were positioned, a start point and time, a release point and time, a final AA to be occupied, a route of march, and an order of march for platoons in the company. The student platoon leader was given about 45 to 60 minutes for planning and troop leading procedures including delivery of an oral platoon OPORD. While the platoon leader prepared his plan and OPORD, the platoon sergeant and TCs carried out some limited preoperation checks that can be done in SIMNET. After the exercise was completed in 30 to 45 minutes, the Team Chief led a platoon AAR lasting 30 to 45 minutes.

After a lunch break, a movement-to-contact exercise was performed during the afternoon of the first day. Team Chiefs occasionally led a walk-through practice on platoon movement. New students were then selected to serve in the leader positions. The sequence was similar to that followed in the road march, with about 60 to 90 minutes allotted to planning and troop leading procedures, 45 to 60 minutes to complete the exercise, and 60 to 90 minutes for an AAR. The OPORD specified an offensive mission with an initial AA, a line of departure, a maneuver axis, and an objective to be occupied. During the exercise, the platoon practiced movement formations, techniques of movement, contact and action drills, and other elements of actions on contact. Enemy contact was simulated by static nonreactive target vehicles at set positions along the maneuver axis and on the objective.

Platoons were paired off to complete two FOF exercises during the second day of SIMNET training. One Team Chief gave his platoon an oral OPORD for an offensive mission, while the other Team Chief gave his platoon an oral OPORD for a defensive mission. Both missions were stated as company-level operations, with other (imaginary) platoons overwatching the movement of the attacker, or with other (imaginary) platoons in positions adjacent to the defender. Movement or firing by the other platoons was not simulated, but the Team Chief occasionally simulated communications with these platoons. Usually, the call to or from another platoon was used to prompt a platoon leader to take some needed action. After completing one exercise in the morning, the platoons switched roles to complete the second exercise in the afternoon. If the AOB class had an odd number of platoons, one platoon operated against a SAFOR platoon.

The OPORD given to the defending platoon specified an initial AA, an initial battle position (BP) to be occupied and defended, a subsequent BP to be prepared, and sectors of fire and kill zones for each BP. The OPORD for the attacking platoon was similar to the offensive mission used the previous day, but set on different terrain. The maneuver axis was designed to lead the attacker through the defender's BP to an objective beyond that position. In this way, the attacker did not know the defender's location in the first exercise, but contact between the platoons was assured if the order was executed properly.

Both the morning and afternoon FOF exercises were performed on the same terrain, with the same OPORDs for the attacker and the defender. Different students were selected for the leader, sergeant, and TC positions in each exercise. While the students were not told that the opponent's OPORD for the second exercise was unchanged from the one they had been given in the first exercise, both platoon leaders usually assumed that this might be the case. Therefore, the leaders' plans for the second exercise used their knowledge of the defender's likely BP, or the attacker's likely axis of advance. The sequence of events in the FOF exercises was similar to that for previous exercises. About 90 to 120 minutes were used for planning and troop leading procedures, 30 to 60 minutes for executing the mission, and 45 to 90 minutes for an AAR led jointly by the Team Chiefs of the opposing platoons.

Observation revealed that the amount and kind of training actually received by platoons in the exercises was highly varied. The students found terrain orientation and navigation difficult in SIMNET. In road marches, they often failed to identify the start point, the correct road at junctions, the release point, or their final assembly area. In movement and FOF exercises, they frequently went off-axis or misidentified their objective. Many platoons spent much of their exercise time lost and wandering over the terrain, forcing the Team Chief to intervene to get the platoon reoriented and back in the exercise. The defending platoon leader often became lost while attempting to reconnoiter the BP, leading to a delay in occupation of the BP by the platoon and a hasty, incomplete preparation of the defense. The defending TCs often missed their assigned firing positions or misidentified their sectors of fire, leaving gaps in the defense. In some instances, the two platoons missed contact entirely so that the exercise was aborted.

Detecting the enemy presented a second kind of common problem that was frequently observed. Sometimes, the defending platoon was able to detect the attackers at long range and wipe them out before the attacking platoon had any clue about the location of the defenders. More often, the attackers came very close to the defenders before either side discovered the other. Frequently, one side would be destroyed before returning a shot. Many exercises ended in a surprise 1-2 minute short range fire

fight, with little chance for fire and maneuver, calls for indirect fire, or spot reports. Attackers often merely practiced the movement aspects of offense, and defenders often practiced just the occupation of their battle position.

In all of the exercises performed in SIMNET, the platoon leader operated under the command of the Team Chief, who acted in the role of a company commander. For the first two classes in SIMNET, the Team Chiefs followed the platoons and observed from a simulated M1 tank, with a TCI serving as a driver. Sometimes an M2 or M3 infantry vehicle was used when a tank module was not available. Another TCI usually accompanied the platoon leader's tank in the place of the student leader, who filled out a short-handed crew on another vehicle. While observing from simulated vehicles, the Team Chiefs found that they often missed important parts of the action, especially when following the attacking platoon. They frequently were caught in poor positions to observe at the most critical time, when initial enemy contact was made. The Team Chiefs also were often in exposed positions to observe and served as targets for the other platoon, many times becoming early casualties. This usually prevented them from seeing anything of the remainder of the exercise, and seriously interfered with their ability to conduct the subsequent AAR.

In subsequent classes, some Team Chiefs observed the exercise using the SIMNET PVD. Starting with the fourth SIMNET class, with the exception of the sixth class, the Stealth Display was also available for use at the same location. This display was not operable for the sixth class because software changes were being made at that time. However, because the PVD can only zoom into one exercise area at a time, and the Stealth Display can only follow one platoon, the Team Chiefs often supplemented their observations by having a senior TCI (usually the Assistant Team Chief) follow the platoon to observe from a simulated vehicle. The area around the PVD and Stealth Display in the CATTC facility was limited and only two radios were provided. These limitations allowed only two Team Chiefs to follow the action and communicate with the platoon leaders from that location. The other Team Chiefs (most often the NCOs) were forced to observe and control the exercise from a simulated vehicle.

AARs were conducted in general correspondence with the procedures outlined in the Mission Training Plan (MTP) for the tank platoon (U.S. Department of the Army, 1988a). Since separate classroom spaces were not available in the SIMNET facility, the AARs were held in passageways separating rows of SIMNET modules. The student platoon leaders used sketch maps on easel pads to describe their plans and the execution of the mission from their point of view. In AARs for FOF exercises, the leaders of the opposing platoons alternated in describing the same phase of the exercise.

During an AAR, the Team Chiefs questioned the platoon leaders and other students to draw out information about events

that were important in determining the success or failure of the mission. The Team Chiefs guided discussion by the platoon to analyze decisions, identify errors of omission or commission, and to formulate alternative actions that might be more effective under the circumstances. In some instances, when pressed for time to complete an AAR, a Team Chief might shorten the process by providing his own critique of the platoon's performance and pointing out the doctrinally correct course of action. Team Chiefs showed characteristic variations in style, ranging from typically socratic to typically directive. The Team Chiefs usually concluded the AAR by going around the group to elicit statements of the main lessons learned by each student.

Field training. The 10-day MTT training period (running nine continuous days) began with a briefing and preoperations maintenance tasks in a motor pool, followed by a road march to a bivouac area, usually on the afternoon of the first day. The students stayed in the field continuously until MTT was finished. The students' crew positions were rotated frequently, normally with new individuals selected to serve as platoon leader, platoon sergeant, and TCs after each exercise. When all students had been either a platoon leader or a platoon sergeant, the students were cycled through these positions for a second time. Usually, every student occupied each of these roles once, in either order. A few students had third evaluations after all other students had been evaluated twice.

The sequence of events followed in the training was similar to that in SIMNET. After the Team Chief gave the platoon leader an oral OPORD, a phase of planning and preparation was followed by mission execution, and then the platoon dismounted to gather together for an AAR. Sometimes, to save travel time, two similar exercises might be completed before an AAR. Usually, the AAR was conducted at a location equipped with a sand table and bleachers. The platoon leader used tank models on the sand table to describe his plan and events occurring during the mission. The Team Chief used the normal methods to lead discussion in the AAR.

Initially, the exercises are similar to those done in SIMNET, with some additions possible with real tanks, terrain, and environmental conditions. Road marches are conducted with logistical exercises including refueling and rearming, and quartering party activities in AAs are fully performed. Movement-to-contact missions provide cross-country practice on platoon formations and movement techniques. Once enemy contact is simulated, the exercises include contact and action drills and other actions on contact, progressing on to hasty attacks with consolidation and reorganization on the objective.

After the first few days devoted to basic techniques of the offense, several defense missions are completed. Groups of two to three offensive and defensive missions are then alternated for several days. Some exercises require night techniques, being done in twilight or dark conditions. Some may be FOF exercises

against a small specially-trained OPFOR unit, with both sides equipped with Multiple Integrated Laser Engagement Simulation (MILES) devices. On the last two to three days of MTT, platoons are combined for a few company-level missions.

ARI observations. Two ARI staff members observed the SIMNET training for each class. The primary purpose was to record any unique incidents that might affect a particular class or platoon. Usually, a staff member stayed with one Team Chief from each pair of platoons. Informal notes were taken on what appeared to be significant events in the planning, execution, and AAR phases of each exercise. TCIs and students were informed that the ARI observers were conducting research sponsored by the Armor School on the use and benefits of SIMNET as an environment for tactical training. If TCIs or students showed interest in the activities of the observers, they were informed that the primary objective of the observations was to see how the SIMNET training was being conducted, and that the purpose was not to evaluate the quality of student performance in SIMNET. The Team Chiefs were fully briefed on the objectives and methodology of the research.

The ARI resources available for this project did not enable collection of objective data or other field observations on the HMMWV training or during the MTT. Therefore, no information was obtained supplementing available records to compare the field training procedures between the baseline and SIMNET-trained classes. The ARI staff members did observe single days of field training on two separate occasions to become familiar with the typical nature of the training procedures used in the MTT.

### Measures

Field training. AOB instructors do not record the number and time duration of individual tactical exercises conducted in MTT. However, TCIs riding with the tanks to observe and train the crews normally evaluate the performance of students that serve in the positions of platoon leader and of platoon sergeant during each exercise. The TCIs use a standard form to record their judgments (FIELD EVALUATION-ARMOR PLATOON TACTICS, Form 1447). The Team Chief directing the exercise reviews and sometimes modifies the TCI evaluations, signing the forms to record his final approval. Notations on the form identify the student and the position occupied during the exercise together with the date, time, and type of mission.

As an indicator of the amount and type of field training conducted in MTT, the number of evaluation forms were counted for several mission categories. Inconsistencies in the available records clearly showed that such counts do not provide an exact accounting of the number of exercises. Frequently, only the day of the exercise was recorded with the time omitted. Recorded times might refer to the start of the exercise or to the time the form was filled out. Evaluations that appeared to be from the same exercise in other respects might list different days,

particularly when it was a night exercise. Varying terms were used to describe the same mission, or the mission identification might be omitted entirely. For these and other similar reasons, it was often difficult to match up records for students in leadership positions in the same exercise and to put the records into a time sequence. Even when most records for a platoon were matched, some single records usually remained unmatched, showing that records were missing or that only one student was evaluated in some exercises. Two platoons that had one or more crews with missing records were discarded from the analysis of evaluation counts, one platoon from the baseline trained classes, and one from the SIMNET trained classes.

Nevertheless, when the day, mission, and position notations on the forms were used in conjunction with certain evaluation items marked N/A (not applicable), consistent classification of records in four mutually exclusive categories was found to be feasible. Numbers of records in these categories provide ordinal measures crudely reflecting the relative frequency of exercises of each type. The four categories are:

1. Movement exercises--road marches, techniques of movement, and movement to contact missions without simulated enemy contact, as indicated by N/A for "reaction to contact" (item I.3.B on Form 1447).

2. Contact exercises--techniques of movement, movement to contact, or offensive missions (prior to the first defense mission) with simulated enemy contact, as indicated by a rating given for "reaction to contact" (item I.3.B on Form 1447).

3. Offense exercises--movement to contact, hasty attack, or deliberate attack missions (after the first defense mission) lacking defensive preparations, as indicated by N/A for "occupation of a battle position" (item I.3.I on Form 1447).

4. Defense exercises--hasty or deliberate occupation of a battle position, hasty defense, or deliberate defense missions with defensive preparations, as indicated by a rating given for "occupation of a battle position" (item I.3.I on Form 1447).

Exercises classified as offense or defense also invariably included simulated enemy contact. Descriptive remarks on the evaluation forms and the number and variety of special tasks required in the exercises (shown in Part I, section 4) showed that the movement and contact exercises conducted in the early days of MTT gradually increased in complexity and difficulty. After the first defense exercise, there were further variations but no pronounced directional trend in difficulty.

The start of defensive training marked a division between two phases of training, from relatively elementary movement and contact exercises to more advanced offense and defense exercises. Corresponding to this division among missions, exercises were

classified as elementary or advanced. The number of elementary exercises is the total number of movement and contact exercises, and the number of advanced exercises is the remaining total number of offense and defense exercises.

One additional measure was taken to indicate the approximate point in time when elementary exercises stopped and advanced exercises began. This measure was the ordinal day of MTT with the first defense exercise for each platoon (often being the first exercise on a new day).

Field performance. Ratings on 17 items from Part I of the FIELD EVALUATION (Form 1447) were used to measure AOB student performance in platoon leader and platoon sergeant positions during field exercises. As shown in Appendix C, Table C-1, the items represent tactical skills in three groupings: (a) planning, (b) movement and control, and (c) conduct of operation. In MTT exercises during 1988, students were rated on the items using a three-point scale with categories labeled Outstanding (O), Average (A), or Below Average (B/A). The later two categories were changed to Satisfactory (S) and Unsatisfactory (U) starting with the first class having MTT exercises in 1989. One item was added to the form at the same time, but this item was not used in the analysis. Both before and after these changes, the evaluator could use a Not Applicable (N/A) category if a rating was inappropriate for any reason.

Student scores were derived by assigning numeric values (+1, 0, and -1) to the three categories (O, A, B/A or O, S, U) and computing the average value for the rated items. A substantial number of items were placed in the N/A category, and this number varied widely among the field evaluation records. Occasional unmarked items were assumed to belong in the N/A category. Items were marked N/A for 24.0% of the first ratings of the students, and 20.5% of the second ratings. Items given N/A were not assigned a value, and did not enter into the average. Therefore, the average was based on 17 minus the number of N/A items. Eight students with 15 or more N/A items on either the first or second rating were deleted from the analysis of field performance. The median number of N/A items was about three for first ratings, and two for second ratings. In both cases, less than 10% of the ratings had 10 or more N/A items.

The field performance ratings had a strong central tendency bias, representing overuse of the central A or S category. For first ratings, 81.3% of the items were rated A or S, and only 11.1% were rated in the O category. For second ratings, the comparable percentages were 75.1% and 18.8%, respectively. This degree of bias may reduce the sensitivity of the performance measure to effects of independent variables.

Before 1988, the same items were present on Form 1447 but the ratings employed a seven-point scale. Since the records of field performance could not be directly compared with later

baseline or SIMNET-trained classes, the MTT exercise ratings for 1987 classes were not analyzed. In addition to the eight students eliminated on the basis of N/A responses, 63 other students were missing one or more ratings, leaving 1282 students with two ratings available for the analysis of field performance.

A fourth group of 10 items in Part I were related to special tasks or situations (reactions to artillery, NBC, obstacles, leader changes, stand to, etc.) that occurred in some exercises, and did not occur in others. The items in this group that were rated were very inconsistent, changing from mission to mission. In addition, usually a majority of these items were assigned to the N/A category. Part II of Form 1447 had 16 items related to general leadership skills demonstrated by the student. These items showed relatively little variation, with the great majority of ratings in the middle (A or S) category. At the same time the scale was changed, five items in Part II were changed so that only 11 common items remained. For these reasons, ratings from these two groups of items were not analyzed.

Graduate evaluation. Ratings on 10 items from Part II of the COMPREHENSIVE STUDENT EVALUATION (Form 1445) were used to derive two measures of the quality of tactical leadership for graduating AOB students. As Appendix C, Table C-2 shows, the items elicit an overall evaluation of general leadership traits demonstrated by the student during the tactics phase of the course. In response to a question asking whether the student possesses each trait, the evaluator answered using a three-point scale, with categories of Yes (Y), Needs Improvement (I), or No (N). The scale had four points in 1987 classes, with Some (SI) and Much (MI) as subcategories under the I rating. An N/A category was available, but was almost never used. Starting with the first class in 1988, the I subcategories were removed, two items on the 1987 (old) form were combined into one item on the new form, and one item was deleted. At the same time, six new items were added to the form. The scale categories or items were not changed for the remaining period examined in this research.

Ratings in the lowest categories were found to be very infrequent. Only 0.38% of the ratings in 1987 were MI or N, and in later classes just 0.15% were N ratings. Furthermore, a majority of students (69%) had perfect ratings (10 of 10 items rated Y). This leaves little room for improvement resulting from training conditions, and makes the results subject to a strong ceiling effect.

The 10 items common to the two forms (with the combined item counted as two items from 1988 onward) were used to derive two measures of graduate quality. The first measure was simply the percentage of items with Y ratings aggregated for each platoon. Group averages for this measure should be mostly sensitive to effects on the minority of students that have several items rated I (SI or MI) or N among the 31% of students that do not have perfect ratings. The second measure is the percentage of

students in the platoon that have perfect ratings. Differences in this measure should be more sensitive to effects on students at the borderline, i. e., students near perfect with just one or two items rated I or N.

Student Characteristics. The students filled in several items of personal information in Part I of Form 1445. The items included his (a) citizenship, (b) source of commission, (c) prior service, and (d) age. Responses to these items were used to examine the similarity of the student samples in the three training groups. Differences in the composition of the groups on such variables indicate selective factors that may be confounded with the training conditions.

### Analyses

Statistical procedures. The statistical analyses used procedures in the Statistical Package for the Social Sciences (Norusis & SPSS, 1988a, 1988b, 1988c; SPSS, 1987). In all analyses, test statistics were judged to be statistically significant with  $\alpha = .05$ . This research was considered to be exploratory, and marginal effects also were examined to suggest hypotheses for further research.

The main independent variables of interest in the analyses were phase, used to estimate the average level of the dependent variable for the three groups distinguished by training condition and rating forms, and week, associated with the trends across time within each phase. The "phase" variable was coded by dummy variables (Draper & Smith, 1966). To assist comparison of trends across analyses, the "week" variable was based on the date that the Comprehensive Student Evaluations were filled out for each class. "Weeks" were counted from a zero reference point set at the week of 1 January 1988.

Initial multivariate analyses of variance (MANOVA) were performed to examine the possible interactions between pairs of independent variables, and whether curvilinear trends were required to model the dependent variables. A second-degree polynomial function of the "week" variable was used to test trend differences between phases. Cubic and other higher degree polynomial components of trend were assumed to be unreliable. Multiple regression analyses were then performed using backward elimination with selected variables to obtain final models describing the effects of the independent variables.

In the analyses of the field performance and graduate quality ratings, first and second powers of "weeks" were residualized (Draper & Smith, 1966) to obtain orthogonal (independent) components of trend. That is, the "week" variable was regressed on the dummy coefficients representing the training phases, and the residual deviations from the "week" average in each phase was used to estimate the linear component of trend in that phase. In turn, the square of "weeks" was regressed on the

"phase" dummy variables and on "weeks" to obtain the residual deviations used to estimate the quadratic components of trend.

The analyses of counts of field evaluations and the measures of graduate quality were based on aggregate platoon data, and used platoons as the sampling unit. The analyses of the field performance ratings used individual students as the sampling unit. In all analyses, dummy variables representing Team Chiefs were forced into the equation first, and the effects of other independent variables were examined after adjustment for (i. e., removal by partialing out) the average differences among Team Chiefs. The RC platoon that was not trained in SIMNET was retained in the analyses to increase the accuracy of the parameter estimate for one Team Chief with only four platoons. Other Team Chiefs that served temporarily and only trained one or two platoons were grouped together in the analyses. For evaluation counts, platoon size was used as an additional covariate to control this factor statistically.

In addition to the "phase" and "week" variables, the analyses of field ratings included day of the MTT, and leader position occupied by the student in the exercise as independent variables. Since only one road march usually occurred on the first day, and only a few students had a rating as late as the tenth day, Day 1 and Day 2 data were combined in the analyses, and Day 9 and Day 10 data was also combined. In the preliminary MANOVA, rating (first or second) was used as a repeated measure variable. However, to simplify interpretation of the results, a separate regression analysis was performed on the first ratings. Then, the first rating was used as an independent variable to analyze measures of residual gain (Cohen & Cohen, 1983) for the second rating. The latter analysis examines effects of the independent variables adjusted for the first rating differences.

Since the percentage measures of graduate quality were near the upper limit of the scale, the inverse sine function was used to convert proportions to angles in radians to improve the normality and homogeneity of variance for these data. A form of the transformation recommended by Bock & Jones (1968) was used, with  $Y = 2 \sin^{-1}(\sqrt{p}) - \pi/2$ , and  $p = (n + \frac{1}{2}) / (N + \frac{1}{2})$ . The effect of the added constants in the formula for  $p$  is to reduce bias in estimating the corresponding population proportion for extreme values near zero or one. The sampling variance of the angular measure is approximately inversely proportional to the number of elements ( $N$ ) contributing to the estimate of  $p$ . On the transformed scale, angular values in radian measure range between  $\pm \pi/2$  corresponding to  $\pm 100\%$ , and zero corresponds to 50%. Analyses were performed on the angular values weighted by the number of students in the platoon. For the analysis of the measure based on the aggregate number of  $Y$  ratings in the platoon, the angular values were also weighted by the number of items rated for each student.

Threats to internal validity. Many factors pointed out as threats to valid inference by Campbell & Stanley (1966) and Cook & Campbell (1979) can affect the comparison between the baseline and SIMNET groups and lead to spurious conclusions. The nature of these factors and their possible manifestations in the results are summarized in Appendix E. Given numerous variables that can have potential influence on the findings, attribution of obtained differences solely to the effects of training factors is not self-evident. Therefore, valid interpretation of the present research findings is beset with hazards. Variables confounded with the training factors must be identified and their effects assessed to the extent that it is possible to do so. Plausible alternative hypotheses must be considered carefully, and conclusions must be qualified and limited as necessary.

## Results

### Field Training

In the baseline classes, the number of evaluations declined gradually for elementary exercises. This decline was in initial movement exercises, rather than the elementary contact exercises. The number of evaluations was reduced further after classes began to be trained in SIMNET, but stabilized at a fairly constant level thereafter. In contrast, for baseline classes, the number of evaluations in advanced exercises varied around an average level. These evaluations gradually increased after the SIMNET training started, although in a somewhat irregular fashion. The number of evaluations per student varied slightly over the baseline and SIMNET training phases.

Elementary exercises. The partial regression model for the trends in total elementary exercises is shown in Figure 1. The negative linear slope in the baseline period is statistically significant,  $t(69) = -2.35$ ,  $p = .022$ . The step down after the baseline is also significant,  $t(69) = -3.06$ ,  $p = .003$ . The regression analysis resulted in multiple  $R = .843$ . The slope and change parameters accounted for 18.5% of the variation among platoons. Appendix D, Table D-1 shows the analysis of variance.

The number of evaluations in elementary exercises combined those in movement exercises with those in contact exercises. When counts of evaluations in these subcategories were examined separately, two entirely different pictures emerged. Regression models for the numbers of evaluations in movement and contact exercises are presented in Figure 2 and Figure 3, respectively. Only the movement exercise evaluations in Figure 2 decreased in number during the baseline phase. On the other hand, only the number of contact exercise evaluations in Figure 3 shifted to a lower level after SIMNET training started. The latter change did not seem to appear for the first two classes trained with SIMNET, but the reliability of this detail cannot be assessed.

In Figure 2, the negative slope of the line is statistically significant,  $t(71) = -6.31$ ,  $p < .0001$ , and in Figure 3, the

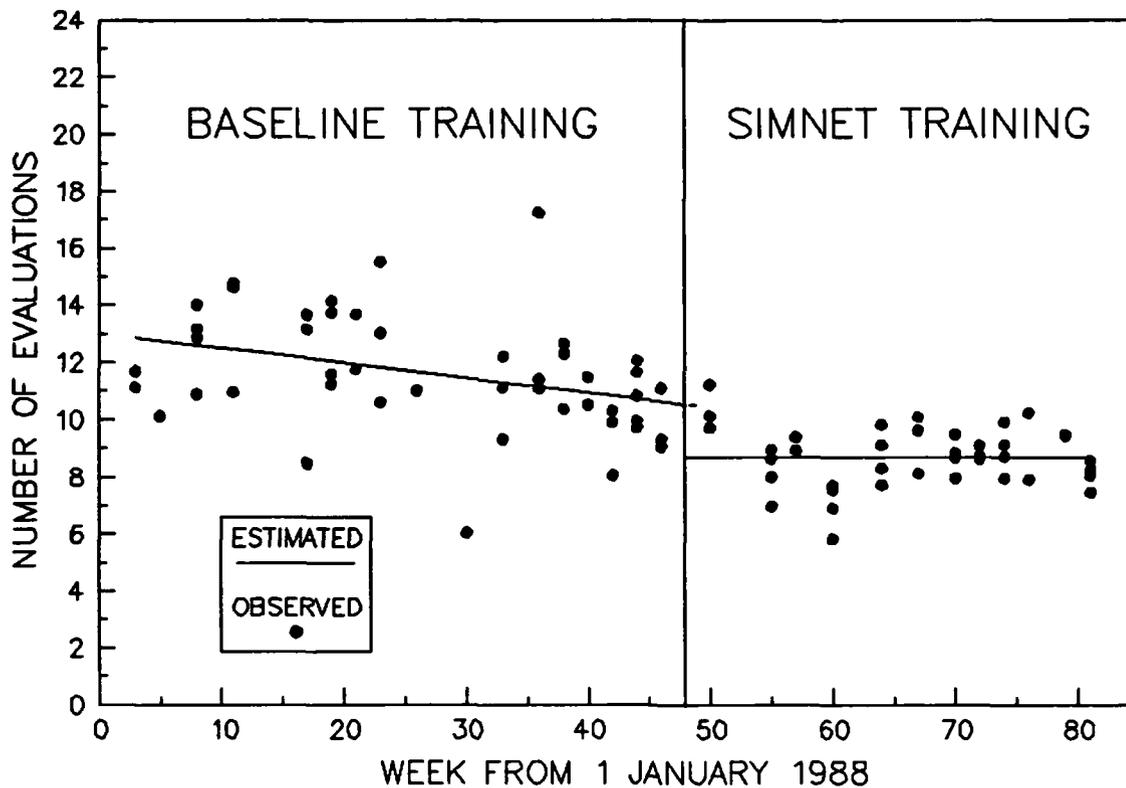


Figure 1. Adjusted number of performance evaluations per platoon for AOB students in elementary exercises during MTT.

change in level is also significant,  $t(71) = -2.01$ ,  $p = .048$ . Multiple  $R = .685$  for the movement exercise data, with the trend line predicting 27.3% of the variation among platoons. Multiple  $R = .770$  for the contact exercise data, with the change in level amounting to just 2.9% of the platoon variation. In this case, Team Chief differences accounted for most of the predictable variation. Appendix D, Table D-1 shows the analyses of variance for these variables. The platoon size factor was insignificant in both analyses, and was removed from the models.

**Advanced exercises.** The upward trend in evaluations did not appear for the advanced exercises until after the first class trained with SIMNET. Figure 4 shows the two-parameter linear regression model for these data. The positive linear slope in the SIMNET training phase is significant,  $t(69) = 2.86$ ,  $p = .006$ . The second parameter estimates the intercept of the line in relation to the average level in the baseline phase, but the initial change in level was estimated to be very small and was not statistically significant,  $t(69) = 0.64$ ,  $p = .523$ . For the movement exercise data, multiple  $R = .819$  with the trend line predicting 15.3% of the variation among platoons. The analysis of variance on the data is presented in Appendix D, Table D-1.

The duration of the MTT did not change in the training schedules that are summarized in Table B-1. An increase in the

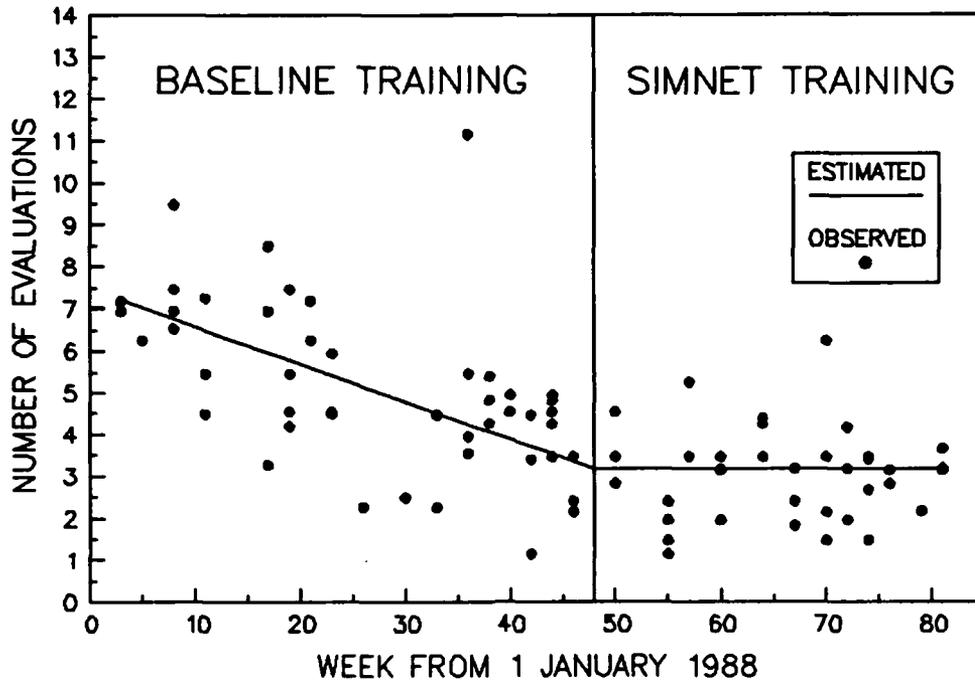


Figure 2. Adjusted number of performance evaluations per platoon for AOB students in movement exercises during MTT.

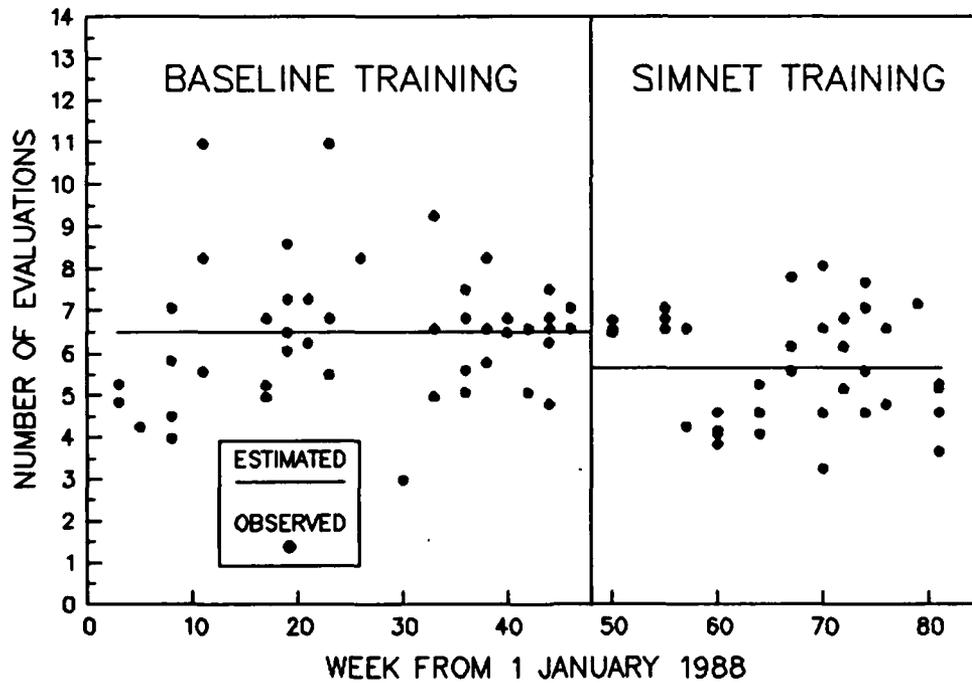


Figure 3. Adjusted number of performance evaluations per platoon for AOB students in contact exercises during MTT.

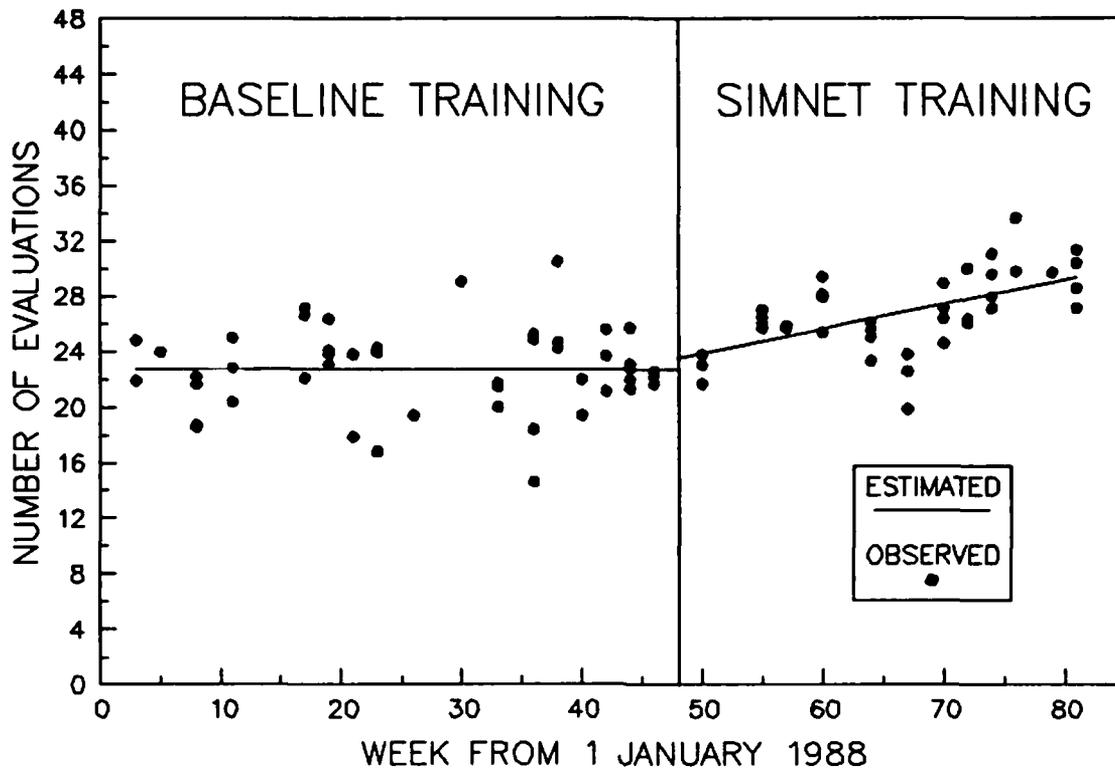


Figure 4. Adjusted number of performance evaluations per platoon for AOB students in advanced exercises during MTT.

number of advanced exercises, inferred from the increase in number of evaluations, suggests that either the exercises were completed more rapidly or that the advanced exercises were started earlier within the MTT. Data on the day of the first defense exercise in the ten-day MTT (that defined the beginning of the advanced exercises) supported the second alternative. Table 2 shows the number of baseline and SIMNET platoons that started their advanced exercises on each day of the MTT. No platoons started advanced exercises after Day 6. The mean day for the baseline group was 4.72 days, and the mean for the SIMNET group was 4.05 days. Based on a rank ordering of days, a shift in time was confirmed by the difference in rank distributions between the groups. A Wilcoxon rank-sum test statistic (Lehmann, 1975) was significant, with  $z = 5.48$ , and  $p < .0001$  using the normal approximation.

Evaluations per student. While evaluations in elementary exercises decreased and those in advanced exercises increased, the ratio of evaluations to the number of students in the platoon changed little, remaining near 2.25, the value of the weighted average. Figure 5 shows the significant linear trends in both training periods. The line had a negative slope in the baseline phase,  $t(69) = -2.04$ ,  $p = .046$ , but the slope was positive in the SIMNET phase, with  $t(69) = 3.61$  and  $p < .001$ . The multiple  $R = .755$  for the ratio data, with the two slope parameters accounting

Table 2

Day of First Defense Mission in Mounted Tactical Training

Day of MTT	Baseline Training		SIMNET Training	
	f	$\bar{x}$	f	$\bar{x}$
3	2	4.2	2	5.3
4	10	21.3	32	84.2
5	34	72.3	4	10.5
6	1	2.1	0	0.0

for only 8.2% of the platoon variation. Appendix D, Table D-1 shows the analysis of variance.

A comparison of the influence of platoon size on the number of evaluations in elementary and advanced exercises is also of interest. For the elementary exercises, the regression coefficient for platoon size was small and not significant, with  $B = .1805$  and  $t(69) = 1.76$ ,  $p = .083$ . For advanced exercises, the coefficient was much larger and statistically significant, with  $B = 1.0911$  and  $t(69) = 6.43$ ,  $p < .0001$ . Using the standard errors for  $B$  estimated in the regression analyses, the difference between these coefficients is significant, with  $t(138) = 4.59$  and  $p < .0001$ . These relations indicate that instructors conducted about the same number of elementary exercises with every platoon, adding about one evaluation (or one-half an exercise) on the average only when the platoon was larger by more than the size of one crew. In contrast, evaluations in the advanced exercises increased in direct proportion to platoon size, with about one evaluation added for each extra student.

Field Performance

Trends in average student ratings across classes changed after the SIMNET and HMMWV were added to the AOB course, showing that this training produced positive transfer to performance in MTT exercises. However, this change was not abrupt. When students were rated for the first time in leader positions in an MTT exercise, their performance increased gradually above the baseline level in successive classes that received the additional training. When students were rated for the second time, their performance in leader positions indicated a similar change in trend, and the first and second ratings were positively correlated. Student learning during the MTT was demonstrated by increases in both ratings across days, and by a tendency to gain from the first to the second rating. However, the size of the gain was very dependent on the Team Chief responsible for the training and the ratings. Performance ratings also were related to the positions, i.e., platoon leader or platoon sergeant, that were occupied by the students in rated exercises.

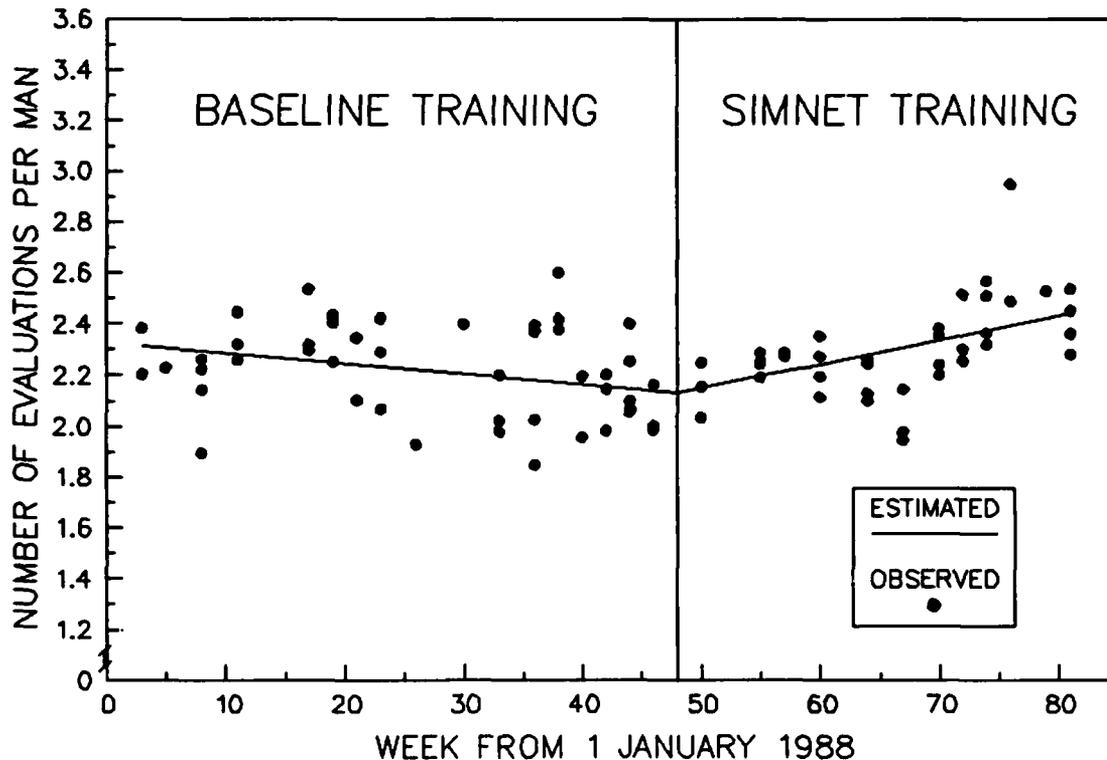


Figure 5. Adjusted ratio of the number of performance evaluations to the number of AOB students in each platoon.

First exercise ratings. Figure 6 shows the partial regression model for the mean first ratings by platoon. In this analysis, the linear trend in the SIMNET training phase was fitted from an intercept representing the average of the SIMNET-trained platoons. This average was greater than the baseline level by 3.52 rating points. The difference was significant,  $t(1263) = 2.18, p = .030$ , indicating that a small overall increase in performance occurred after the baseline period. This effect shows that the training added before the MTT produced additional transfer of training to the field exercises. However, this transfer of training effect developed gradually from the baseline level. In Figure 6, the trend line in the SIMNET phase had a significant positive slope,  $t(1263) = 2.37, p = .018$ . This result shows that student performance was higher in the later SIMNET-trained classes, and therefore the amount of transfer increased gradually for successive classes.

Multiple  $R = .358$  for the first exercise ratings, with 2.1% of the student variation predicted from the regression model, and another 12.3% from Team Chief differences. Besides the slope and intercept of the trend for the SIMNET classes, the model had parameters for the student's position in exercises rated first and second, and linear and quadratic parameters for a trend across days in the MTT. Appendix D, Table D-2 shows the analysis of variance. The leader position occupied by the student for his first rating had a significant effect,  $t(1263) = 2.58, p = .010$ .

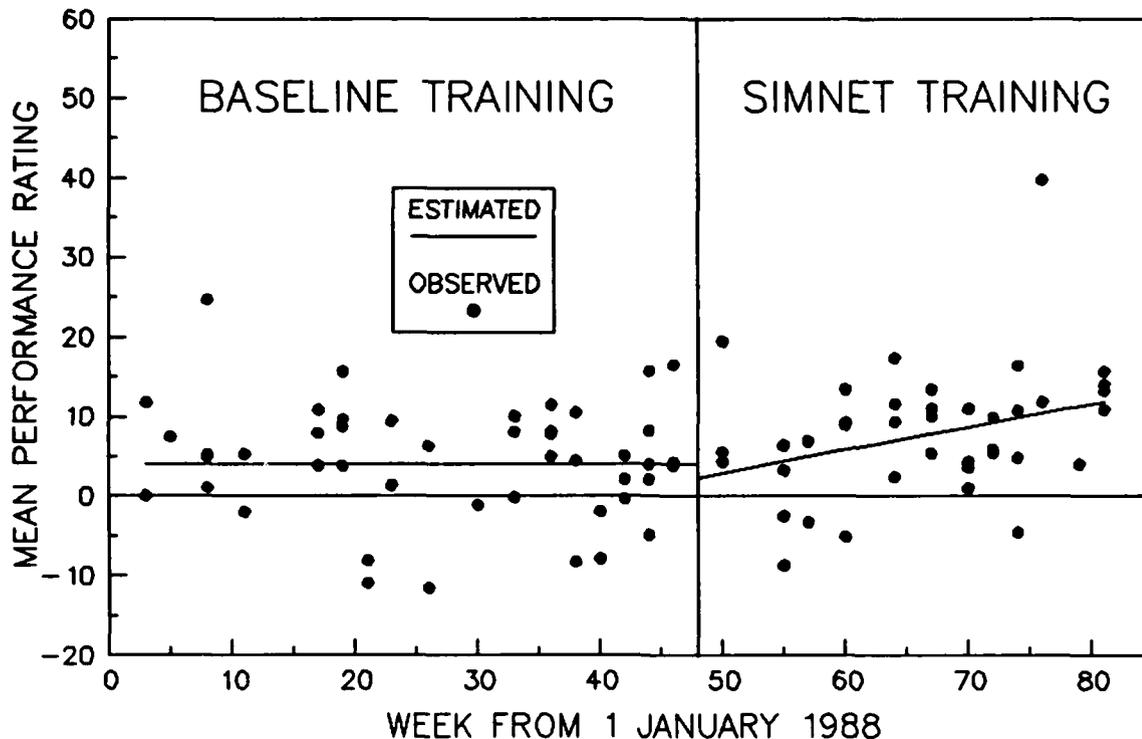


Figure 6. Adjusted mean performance rating by platoon for AOB students in their first exercise rated during MTT. Rating values can range from 100 to -100.

A more surprising result was that the first rating also was affected significantly by the student's position for his second rating,  $t(1263) = 3.09$ ,  $p = .020$ . Finally, the first ratings increased over successive days of the MTT, indicating that students learned during previous field exercises, even though they had not served in a MTT leadership position before their first rating in an exercise. In addition to the significant linear component,  $t(1263) = 3.49$ ,  $p < .001$ , a quadratic component of the day trend also was significant,  $t(1263) = 2.24$ ,  $p = .025$ . The latter effect demonstrates that the trend was curvilinear, showing that the rate of improvement did not remain constant over days. The nature of the day trend is examined further in a later section of the report.

Figure 7 shows the differences in first ratings associated with leader positions in rated exercises. The average rating for students rated first as a platoon leader (the two bars on the left in Figure 7) was lower than the average for those rated as a platoon sergeant (the two bars to the right of Figure 7). This finding was expected, as the platoon leader has a more difficult job and greater responsibility for the success of the platoon's mission. Furthermore, the TCIs and Team Chiefs who rate student performance may set a higher standard for a student acting as platoon leader because of the larger impact of his mistakes,

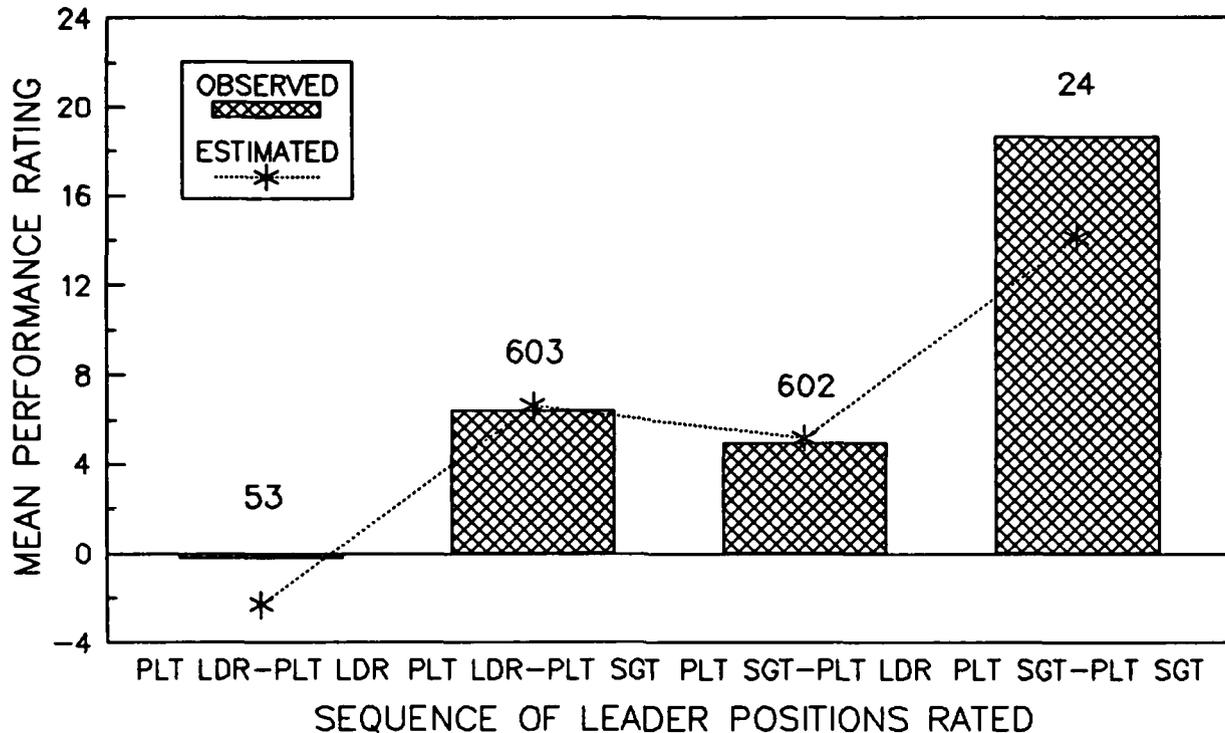


Figure 7. Effect of first and second positions as a leader on the adjusted mean performance of AOB students in their first exercise rated during the MTT. The number of students is shown above the bar for each sequence of positions. Rating values can range from 100 to -100.

while scrutinizing less closely the actions of the student in the platoon sergeant position and rating him more leniently. Student selection is another factor that could account for the rating difference. Less able students might be placed more often in the platoon leader position for their first rating in an exercise. One additional bit of evidence is available to distinguish between these explanations. As the numbers of students in each position sequence indicate in Figure 7, the large majority of students were rated in both positions. The first ratings were very similar for students who were rated in both positions. The equivalence of ratings for these two subgroups implies that difficulty or rating bias effects were absent for these students. Therefore, selection is probably entirely responsible for the effect of the first position on the first ratings.

Differences in the first ratings related to the position occupied by students in exercises rated second are not subject to possible causal interpretations. Selection seems to be the only viable hypothesis in this case. The first rating cannot be directly affected by the actions of the student, TCI, or Team Chief that occur at a later point in time. Thus, explanations based on the difficulty of positions or rating bias do not apply.

Apparently a small number of less able students are sometimes chosen for extra practice as platoon leaders, while a small number of superior students are assigned to serve as platoon sergeants for both their first and second rating. Some of the latter students may later be rated for a third time as a platoon leader in a company level exercise at the end of the MTT, but third-rating data was not examined in this research.

The mean first rating was 8.04 for the 36 students who were missing a second rating and therefore were discarded from the analysis. This mean was not significantly larger than the 5.72 mean value for the 1282 students who remain in the analysis,  $t(1316) = 0.432$ ,  $p = .666$ . The deletion of this small group of students should not have introduced an important selective bias in the analysis of the first ratings.

Relation between ratings. The correlation between the first and second ratings was modest,  $r = .362$ , but highly significant for this large sample of students,  $t(1280) = 13.89$ ,  $p < .0001$ . The mean of the first ratings was 5.72, increasing to 12.59 at the second rating. This is the apparent gain resulting from practice in a leader position in the student's first exercise that was rated. However, this gain is partially confounded by the difference in days, since the exercise rated second always comes after the first, either on the same day or a later day. Since performance increases over days, a positive change in rating can be expected even without a direct effect of practice.

With rating differences adjusted for day, position, and Team Chief effects in a repeated-measure MANOVA, the mean change was reduced to 5.25. This change approached significance,  $t(1256) = 1.63$ ,  $p = .104$ . However, the gains did differ significantly among Team Chiefs,  $F(10,1256) = 3.29$ ,  $p < .0001$ . If the Team Chiefs are considered a random factor, and the Rating x Team Chief interaction is used as the error variance, the overall average gain would not be significant,  $F < 1$ . Therefore, the overall positive change in performance was not reliable, but depended on the instructor who guided the training.

Further analysis of differences between first and second ratings showed that these gains were independent of the "phase" and "week" variables. Inspection of the gains also did not reveal any substantial tendencies toward systematic changes over time. After regression on the day, position, and Team Chief variables, neither the effect of the average level,  $t(1262) = -0.37$ ,  $p = .709$ , nor the linear trend,  $t(1262) = -0.85$ ,  $p = .395$ , were significant. Thus, except for random variation and other effects, the improvement in rating from the first to the second exercise remained roughly constant. This is an important aspect of the results, since it means that the transfer effects on the first rating in the SIMNET training phase carried over to the second rating, and were not offset by a difference in gains.

Second exercise ratings. The regression analysis of the second rating data used the first rating as a covariate to remove that portion of the second rating correlated with the first. After this adjustment, the so-called residual gains show the effects of independent variables free of their correlated effects on the first rating. Partial  $r = .288$  between the two ratings, showing that a significant relationship remained after adjusting for Team Chief differences,  $t(1269) = 10.70$ ,  $p < .0001$ .

The final multiple  $R = .449$  for this analysis, with the first rating predicting 7.2% of the student variation, and two other regression parameters accounting for an additional 1.3%. Appendix D, Table D-2 shows the analysis of variance. The slope of the linear trend over MTT days was significant,  $t(1266) = 3.76$ ,  $p = .002$ , indicating student learning. This result is presented in the next section of the report. The second finding was that the ratings for SIMNET-trained students differed by position, but baseline students did not differ. This Position by Phase interaction is shown in Figure 8.

The platoon leaders obtained somewhat higher ratings than the platoon sergeants in the SIMNET phase, which is an effect opposite to that observed for the first ratings. In contrast, the adjusted means for platoon leaders and platoon sergeants were very similar in the Baseline phase. All four of these means were close to unadjusted values, indicating that these position effects were relatively independent of the first ratings, and of the position effects found in those ratings.

In the Baseline phase, the residual gains for students rated in the platoon leader position in their second exercise were a bit larger, 6.81, than the gains for those rated as platoon sergeants, 3.51. This difference offset the difference observed in the first rating, to make the second ratings nearly equal. This difference was enlarged in the SIMNET phase, with residual gains amounting to 10.51 for students rated second as platoon leaders and -0.72 for those rated as platoon sergeants, resulting in the effect on the second rating that is shown in Figure 8.

Several possible factors may have contributed to the position effects. If selection produced the position differences for the first ratings, then the training added (both SIMNET and HMMWV) after the baseline may have helped the poorer students more than others. The training changes may have modified the emphasis of the field training to focus more on specific platoon leader duties and less on platoon sergeant duties, so student performance improved more in the former position, and decreased a little in the latter position. The advanced exercises that were conducted earlier in the SIMNET phase of the MTT may have helped students become more capable of performing in the platoon leader position by the time of their second exercise rating, while this more advanced training was less beneficial to performance as a platoon sergeant. The present evidence is not sufficient to discard any of these hypotheses, nor other more complicated ones.

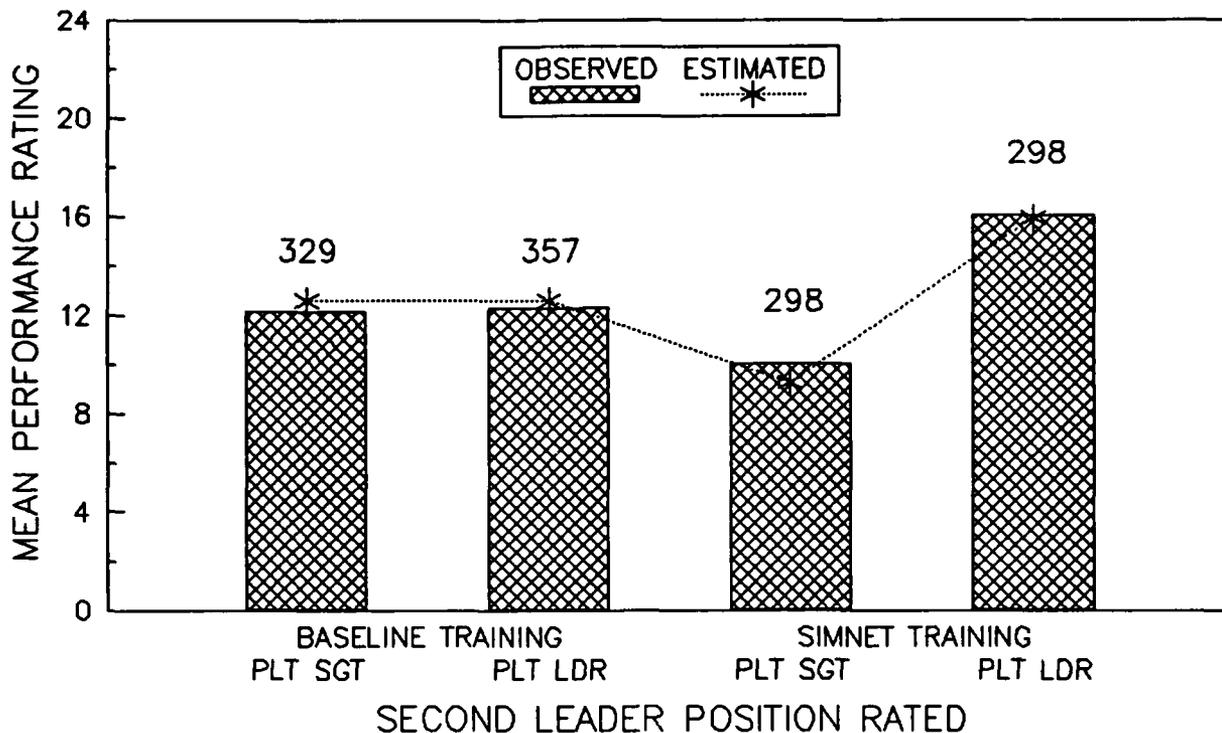


Figure 8. Effect of leader positions on the adjusted mean performance of AOB students in their second exercise rated during MTT. The number of students is shown above the bar for each leader position. Rating values can range from 100 to -100.

The mean second rating for the 12 students whose first ratings were missing was 13.91. These students were omitted from the analysis, but their mean did not differ significantly from the mean second rating, 12.59, for other students that remained in the analysis,  $t(1316) = 0.102, p = .459$ . The selective bias produced by discarding this small group of students should have little effect on the analysis of the second ratings.

Trends across days in MTT. The changes in performance from day-to-day during the MTT is shown in Figure 9. This graph represents the overall learning curve for the entire sample of AOB students combining the trends obtained in the analyses of the first and second ratings. Performance did not increase much until after the fourth day, corresponding to the start of the advanced exercises. During the earlier days when the exercises increased in difficulty, performance stayed at a fairly constant level. After the difficulty level of the exercises stabilized, learning became evident in the performance ratings.

The trends across days that were combined in Figure 9 are presented separately in Table 3. The values show the quadratic regression obtained in the analysis of the first exercise ratings, and the linear regression obtained in the analysis of

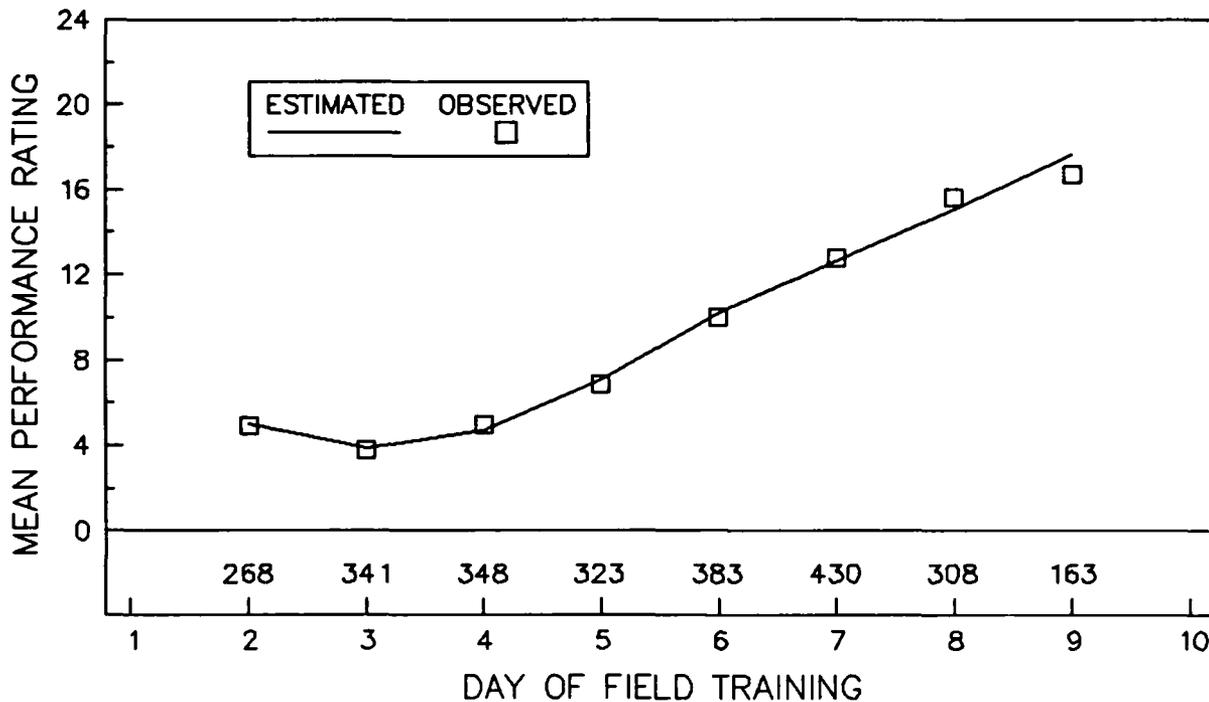


Figure 9. Increase in weighted adjusted mean performance rating combining the first and second rated exercises for AOB students. The number of ratings combined at each training day is shown above the abscissa. Rating values can range from 100 to -100.

the second ratings. The fit between observed adjusted means and the estimated values predicted from the regression models is reasonably close, except for some of the days with a small number of ratings. The numbers of student ratings for each day call attention to the fact that the early portion of the learning curve is largely based on the students' first ratings, while the latter portion of the curve is based mostly on second ratings.

The preliminary analyses did not show any significant evidence that the day trends in Table 3 changed when the SIMNET and HMMWV training was added to the course, or when the advanced exercises were started sooner in the MTT. When the advanced exercises were started on an earlier day, the greater difficulty of the exercises on that day might have reduced the performance ratings, at least for exercises rated first. Since no reliable effect of this kind was obtained, apparently the students were able to handle more difficult exercise situations while keeping their performance at a similar level. This suggests that the advanced exercises were started earlier when the instructors noticed the students' progress and believed they were able to execute more difficult missions. The earlier start then allowed a greater number of advanced exercises to be completed within the limited time of the MTT. Therefore, the performance changes

Table 3

Mean Field Evaluation Ratings on Successive Days of MTT

Day	First Exercise Ratings			Second Exercise Ratings		
	N	Est.	Obs.	N	Est.	Obs.
2	268	4.99	4.94			
3	320	3.99	3.85	21	2.14	2.44
4	328	4.68	5.22	20	4.73	0.77
5	244	7.05	6.41	79	7.32	8.42
6	102	11.11	11.19	281	9.90	9.60
7	20	16.86	18.04	410	12.49	12.57
8				308	15.07	15.67
9				163	17.66	16.72

Note. Evaluations on Day 1 were combined with those on Day 2, and evaluations on Day 10 were combined with Day 9.

resulting from increased transfer of training were probably a cause, not an effect, of the training change observed in the MTT.

Graduate Evaluation

Both measures of graduate quality tended to decrease linearly in the baseline classes, and showed a curvilinear trend in classes after the SIMNET and HMMWV training were added to the AOB course. The variation among platoons was substantial for these measures, and the best-fit trends were not statistically significant. However, there was evidence that graduate quality increased after the first class given training in SIMNET.

"Perfect" student ratings. The quality of AOB graduates declined slowly across the baseline period, when measured by the transformed percentage of students who had all 10 items with ratings in the highest category, i.e., students who were rated as "perfect." A shift in the probability of "perfect" ratings when the rating form changed (at Week 0) offset the decline in the first segment of the baseline, so that the average level of this measure was about the same for baseline classes rated with the old and new forms. After the baseline, the first class showed relatively high values on this measure, followed by lower values for several classes, and a subsequent recovery to higher values again in later classes.

A four-parameter model illustrating these trends is presented in Figure 10. The model components were chosen to allow comparison with trends in previous figures. The baseline trend was assumed to have the same slope with both rating forms. It should also be noted that the differences indicated by the

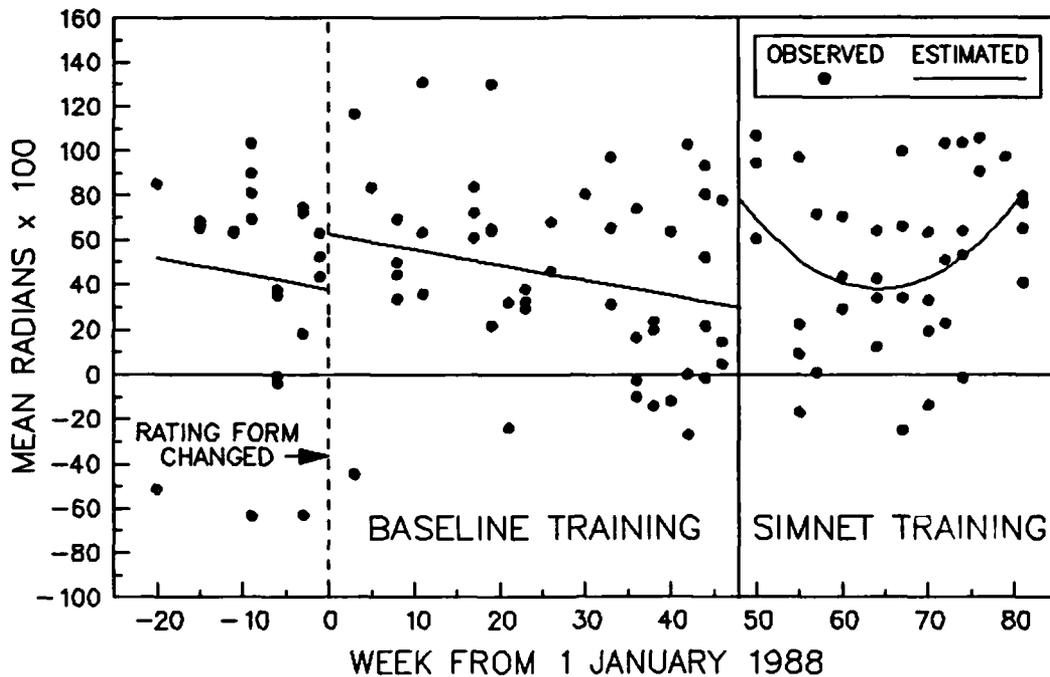


Figure 10. Adjusted transformed percentage of students in AOB platoons with "perfect" ratings on the Comprehensive Student Evaluation. Angular values can range from  $100\pi/2$  to  $-100\pi/2$ .

trends in Figure 10 are moderate when the transformed values are related to the original percentage scale. The intercept of the linear trend at Week 48 corresponds to 64.6%, while the endpoints of the curvilinear trend in the SIMNET phase average 85.7%.

Considerable variation among platoons is evident in Figure 10, including several deviant platoons in the early baseline classes that fell much below the estimated values predicted from the model. Four platoons had Studentized-deleted residuals (Norusis & SPSS, 1988b) greater than 2.56. Approximately one such value can be expected in a sample of this size. No rational basis for discarding these platoons was discovered. Although they can be regarded as outliers in statistical terms, each platoon was associated with a different Team Chief, and their other records were not unusual. With all platoons included in the analysis,  $R = .647$  for the multiple regression. Team Chief differences were responsible for 38.5% of the platoon variation, with just 3.4% associated with the model parameters. In the analysis shown in Appendix D, Table D-3, the additional variance predicted by the model parameters was not significant. Tests on the individual parameters also proved to be nonsignificant.

Although the regression analysis did not statistically confirm the trends shown in Figure 10, further examination suggests that graduate quality increased after the first SIMNET trained class. Omitting platoons in this class, the reliability of the apparent increase in the later classes was supported by a

Spearman rank-order correlation between Weeks and the transformed percentage values, adjusted for Team Chiefs differences by platoon (the "OBSERVED" points in Figure 10). The correlation coefficient was  $r = .368$ , and this value was significantly greater than zero,  $t(34) = 2.31$ ,  $p = .026$ .

Platoon aggregate ratings. Graduate quality, as measured by the transformed platoon percentages of items rated in the highest category, showed trends similar to the transformed percentages of "perfect" students. A comparable four-parameter model for these data is presented in Figure 11. The declining trend for the baseline platoons, with little overall difference between forms, was followed by a curvilinear trend for the SIMNET-trained platoons. However, in this case the curve started closer to the baseline level, and reached a higher level at the end. The differences are small when the transformed values are related to the original scale. The intercept of the baseline trend at week 48 represents 92.9%, while the curve in the SIMNET phase started at 96.7% and increased to 98.7% at the end.

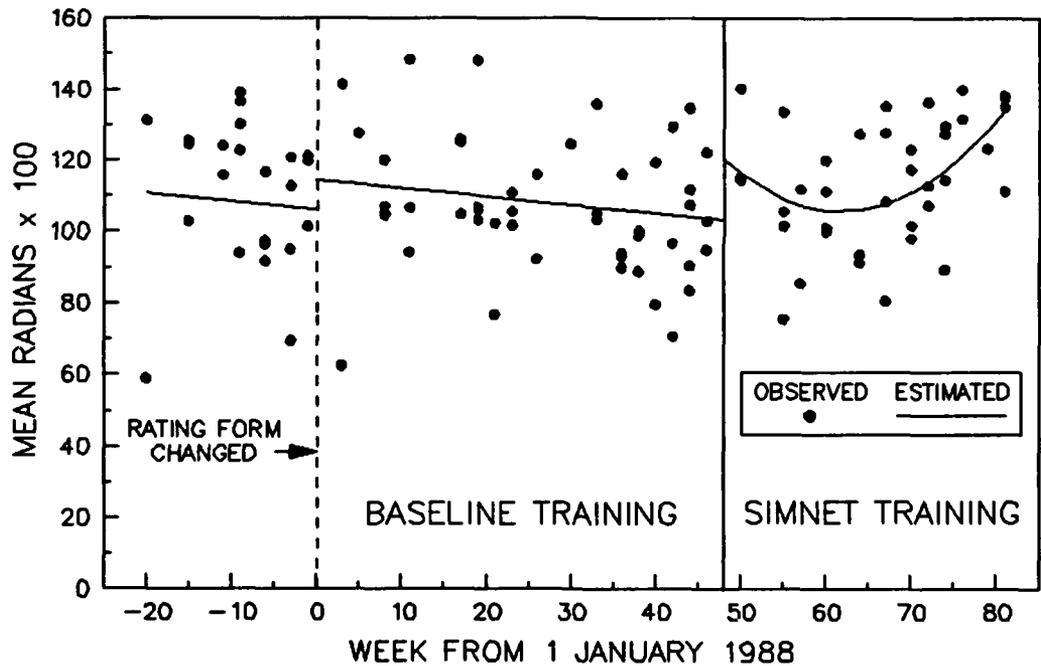


Figure 11. Adjusted mean transformed percentage of items rated "yes" on the Comprehensive Student Evaluation for AOB platoons. Angular values can range from  $100\pi/2$  to  $-100\pi/2$ .

For the four-parameter model,  $R = .688$ , with the Team Chiefs responsible for 43.2% of the platoon variation, and the model accounting for an additional 4.1%. The variance predicted by the model was not significant in the regression analysis shown in Appendix D, Table D-3, and tests of each model parameter also were nonsignificant. Two deviant platoons were found in these data, with Studentized-deleted residuals greater than 2.90. With

the first SIMNET-trained class omitted, the Spearman rank-order correlation between Weeks and the adjusted mean transformed values for platoons was  $r = .523$ , indicating a positive trend in graduate quality after Week 55. This correlation coefficient was significantly greater than zero, with  $t(34) = 3.58$ ,  $p < .002$ .

Student Characteristics

Citizenship. The sample of AOB students included a small number of foreign students. Just 22 students, or 1.3% of the sample, did not provide citizenship information on Form 1445. Among those responding, 3.1% were foreign students. Inspection of the data indicated that foreign students were not concentrated in any particular classes or platoons. No class had more than three foreign students, and no platoon had more than two such students. Table 4 shows the breakdown of students in the three training groups. The slight differences between groups were not statistically significant,  $\chi^2(4, N = 1705) = 2.91$ ,  $p = .57$ .

Table 4

Citizenship of AOB Students in Segments of Training

Citizenship	Baseline Training		SIMNET Tng New Form
	Old Form	New Form	
United States	94.3	95.8	96.2
Foreign	4.3	2.7	2.8
Missing Data	1.4	1.5	1.0

Note. The values are percentages within each training group.

Source of commission. A majority of students obtained their commission through the Reserve Officer Training Corps (ROTC). Some 55 students, or 3.2%, did not provide this information. Among the remaining students, 66.0% were from ROTC, 13.4% were graduates of a U.S. military academy (either West Point, or Annapolis for Marine officers), and 17.3% attended Officer Candidate School (OCS). The other 3.3% of students were U.S. citizens from a domestic military college, or foreign students that have various paths to a commission.

The three training groups had very different distributions among these categories. Table 5 shows the breakdown for each group. The percentage of academy graduates was relatively high in the first phase of the research (Baseline-Old Form group), but the percentage was very small in the third phase (SIMNET Training group). Conversely, the percentage of ROTC students increased

Table 5

## Source of Commission for AOB Students in Segments of Training

Source of Commission	Baseline Training		SIMNET Tng New Form
	Old Form	New Form	
USMA <sup>a</sup>	32.7	12.7	1.8
ROTC <sup>b</sup>	48.3	58.6	79.4
OCS <sup>c</sup>	12.5	21.2	13.8
Other <sup>d</sup>	3.1	3.9	2.3
Missing Data	3.4	3.6	2.6

Note. The values are percentages within each training group.

<sup>a</sup>U.S. Military Academy (Army or Navy). <sup>b</sup>U.S. Reserve Officer Training Corps. <sup>c</sup>U.S. Army or Marine Officer Candidate School. <sup>d</sup>Other military colleges or schools.

across the three phases. In contrast, the OCS graduates had a larger percentage in the middle phase (Baseline-New Form group).

The differences in distribution among the three training groups were statistically significant,  $\chi^2(10, N = 1705) = 224.97$ ,  $p < .0001$ . Comparing the nonmissing data pairwise for groups adjacent in time, the differences between the two Baseline groups were significant,  $\chi^2(3, N = 1059) = 64.40$ ,  $p < .0001$ , and the differences between the Baseline and SIMNET groups with the New Form were significant,  $\chi^2(3, N = 1310) = 84.93$ ,  $p < .0001$ . The Baseline-Old Form group also differed significantly from the SIMNET group,  $\chi^2(3, N = 931) = 194.47$ ,  $p < .0001$ . The group differences appear to be associated with seasonal variations in AOB accessions. Most academy graduates appear to report for the course in the summer and early fall months. The first phase of the research covers only the latter half of a year, so academy graduates are over-represented in the first group. The second phase covers a full year, so the second group has more balanced representation. The third phase only includes classes in the first half-year, so the third group had few academy graduates.

Prior service. Table 6 shows the categories of information provided on prior service. About one-third of the students indicated some prior service experience. Although this item called for the branch and military occupational specialty in that service, many students identified a unit, which permitted the service to be categorized as active or reserve. It was unclear

whether the students understood the service to be listed was that performed prior to commissioning. Nearly one-third of the students had missing data for this item. This includes many students who left the item blank, and may have intended a nonresponse to indicate no service.

Table 6

Prior Service for AOB Students in Segments of Training

Prior Service	Baseline Training		SIMNET Tng New Form
	Old Form	New Form	
No Service	32.9	37.0	31.8
Some Active	6.5	10.9	9.0
Some Reserve	7.1	15.3	10.5
Ambiguous <sup>a</sup>	13.1	8.6	20.1
Missing Data	40.3	28.3	29.5

Note. The values are percentages within each training group.

<sup>a</sup>The response did not clearly indicate service performed with an active or reserve unit.

Although the differences are difficult to interpret, comparison of the response distributions showed statistically significant differences were found among the three training groups,  $\chi^2(8, N = 1705) = 68.38, p < .0001$ . Omitting the students with missing data and computing percentages for the remaining students, the students that reported no service decreased from 55.2%, to 51.6, and to 43.2% in the three training groups. The differences among the percentages were statistically significant,  $\chi^2(2, N = 1159) = 68.38, p < .0001$ . This change may have been associated with the decreasing proportion of students with academy commissions across the three groups.

Chronological age. The average age of the AOB students in this sample was 24.11 years, with a within-groups standard deviation of 2.59 years. Some 38 students, or 2.2%, did not report their age on Form 1445. Table 7 shows the summary statistics separately for each training group. The students in the Baseline-Old Form group were a little more than one-half year younger than the students in the other groups. This result reflected the lesser average age of Academy graduates compared to other AOB students, especially ones from OCS.

Analysis of variance indicated significant differences among the three training group means,  $F(2,1664) = 7.79$ ,  $p < .001$ . Comparing pairs of groups, the mean for the Baseline-Old Form group differed significantly from means both for the Baseline-New Form group,  $t(1073) = 3.86$ ,  $p < .001$ , and for the SIMNET-New Form group,  $t(935) = 3.11$ ,  $p < .001$ . Means for the latter two groups did not differ significantly,  $t(1320) = 0.92$ ,  $p = .18$ .

Table 7

Age of AOB Students in Segments of Training

Statistic	Baseline Training		SIMNET Trng New Form
	Old Form	New Form	
Mean Years of Age	23.63	24.30	24.16
Standard Deviation	2.43	2.70	2.54
Number of Students	345	730	592
Missing Data	2.0%	2.1%	2.5%

Discussion

The tactical training added to the AOB Course was associated with three major effects. First, elementary contact exercises conducted in the MTT decreased in number, and were gradually replaced by additional advanced exercises involving defense and offense missions. Second, positive transfer in terms of improved field exercise performance in the MTT emerged gradually after the pre-MTT training was expanded by SIMNET training and HMMWV field exercises. Third, there were indications that the transfer effect persisted to enhance the quality of AOB graduates, at least for the last classes examined. Attributing these effects to specific causal factors is not so straightforward.

Clear cut and definitive inferences about the effects of SIMNET training are hindered by multiple confounded variables that might influence the results of AOB tactical training. However, giving careful consideration to all of the possible effects can provide a better understanding of the processes that may be reflected in the results, and yield some insights that may be helpful to decision makers. Given the limitations of other information available, even a tentative best guess about the value and limitations of SIMNET in training can guide the use of networked simulators.

In the next section, two alternative interpretations of the possible transfer of training effects obtained in the results are

presented and discussed. Then, some likely effects of variables that were confounded with the training added to the AOB Course are summarized. Finally, implications of the results for device testing and unit training are discussed.

### Transfer of Training

Two alternative views about the transfer of training effects must be examined as competing interpretations of the main results in this research. These views are:

1. The additional AOB training produced an immediate benefit in terms of transfer of training (i.e., a general gain in the level of learning and performance relative to the preexisting baseline training conditions). However, this benefit was offset temporarily after the first post-baseline class by interfering factors. The interfering factors prevented full expression of the training benefit for several classes until those factors were removed or their influence otherwise diminished in later classes.

2. The additional AOB training had little or no beneficial effect initially, but there was a gradually developing and progressive trend of improvement in transfer of training across time and successive classes. In the later classes represented in the sample, the added training then produced benefits that definitely exceed the baseline level. Other factors did not have a major interfering effect, but may account for some variations around the main trend.

Each of these views is consistent with some aspects of the results obtained in this research. The first interpretation is consistent with the abrupt decrease in the number of elementary exercises, as indicated by the number of student evaluations. This decrease took place after the first SIMNET-trained class, consistent with other evidence that training changes were contingent on the perception of improved student performance by the instructors. Contact exercises accounted for most of the decrease in the number of elementary exercises for the SIMNET-trained classes compared to the baseline. The differences in ratings between student leadership positions indicated a general improvement in performance of platoon leader duties occurred for the exercises evaluated second, and that learning was enhanced to produce greater gains for the poorest students in relation to that position. Measures of graduate quality tended to suggest a curvilinear trend for classes after the baseline, although the reliability of the trend is questionable on statistical grounds. Nevertheless, if a U-shaped effect was present in those data, the pattern of the results is consistent with a general improvement in the level of graduate quality shown by the limbs of the curve, interrupted by an intermediate period of reduced quality.

On the other hand, trends for other dependent variables are more in line with the second interpretation. Performance in the field exercises seemed to increase gradually after the baseline

classes. Only one platoon in the first class trained with SIMNET signified an abrupt change in the first exercise ratings, with a substantial positive deviation from the regression line. Also, performance was relatively low for some platoons in the second and third classes, with the improvement in performance emerging in subsequent classes. A gradually increasing overall trend was clear in the number of advanced exercises, inferred from the number of student evaluations. Sizable negative deviations from this trend showing some kind of interference were apparent only for platoons in the sixth SIMNET class. At the same time, the gain in number of advanced exercises was most evident after the seventh SIMNET class following improved performance ratings in the fifth and sixth such classes, again consistent with the interpretation of the causal relation between performance and the amount of advanced training. Finally, the existence of a gradually increasing level of graduate quality in SIMNET-trained classes was supported by the post hoc rank-order correlations obtained for both measures when the first such class was removed from the sample.

Aside from the points of disagreement, both interpretations share one common feature: that the added training was beneficial to AOB students in the last classes examined, and that the benefit was at least maintained, and appeared to be continuing in an upward trend when further data collection was concluded. This inference is supported by all the data examined, and is the one unambiguous finding that can be derived from the results. Based on this finding, it can be concluded that the addition of some combination of SIMNET and HMMWV training produced positive transfer to tactical performance in the field. The timing of the transfer effect remains at issue, i.e., whether the effect was immediate or delayed in relation to the change in training conditions. A second problem connected with that conclusion is how to assess the relative contribution made by the SIMNET training compared to that made by the HMMWV training.

### Effects of Confounded Factors

Factors involving several types of threats to valid inference are identified and examined in detail in Appendix E. Effects of variables associated with each factor are considered in relation to their possible bearing on the alternative interpretations presented above. These effects are also examined to see what aspects or portions of training transfer might be traceable to SIMNET or to HMMWV practice. Other interpretations and hypotheses suggested by the confounded variables are also considered. Only the most plausible effects discussed in Appendix E are summarized here.

Effects on transfer. The apparent increases in transfer of training and graduate quality are probably causally related to an important maturational variable that was inherently confounded with the sequence of classes after the baseline: the instructors' increasing experience in training students in SIMNET. At the

same time, observations of SIMNET training indicated that the effectiveness of the training tended to increase as instructors, both individually and as a group, gained experience in using that environment. Therefore, the preponderance of evidence supports the second viewpoint on the transfer effects, that transfer gradually increased. The tentative conclusion is that improved SIMNET training was primarily responsible for the obtained increases in field exercise performance and in the amount of advanced training, and for the possible increase observed in graduate quality. A change in the rating scale used for the field evaluations after the first SIMNET-trained class may have reduced the degree of positive transfer measured by field performance ratings, detracting from transfer that might otherwise be attributed to the HMMWV training. Other evidence suggests that the benefit of HMMWV training, if any, was a contribution to some portion of the constant savings in the number of contact exercises.

Other trend-obscuring effects. Abnormally elevated measures of graduate quality for the first class trained in SIMNET may have resulted from participation in an advanced gunnery exercise, or from a rating bias produced by initial expectations about the benefits of SIMNET. Seasonal factors did not appear to have much effect on the overall trends in the results. The tendency for graduate quality to decline during the baseline period may be attributed either to gradually increasing rating standards or to an observed decrease in the proportion of military academy graduates in AOB classes. The factors of selection and loss of data did not seem to have any important influence on the major findings related to transfer of training.

#### Implications for Device Testing

Convincing objective evidence for the effectiveness of military training devices has frequently been difficult to obtain, given the practical difficulties of conducting transfer experiments in training settings. Boldovici (1987) discussed many of the pitfalls. He pointed out that results often show no statistically significant difference between practicing with a device and an operational weapon system, or no positive transfer of training when device training is compared to appropriate control conditions. Such results have often been used to draw fallacious inferences about the effectiveness of a device, or its lack of effectiveness.

One of the major problems has been the frequent use of samples that are too small in relation to the variability of performance, so that the statistical power to detect differences of a reasonable size has been inadequate. This problem is exacerbated for a collective training device like SIMNET, since the primary sampling unit for the measurement of collective performance is an intact military unit, such as a platoon, company, or battalion, according to the echelon of the tasks being trained. Obtaining intact units to support tests of SIMNET

training has been very difficult to arrange, and the one test that has been completed used a very small number of platoons.

The present results demonstrate that quasi-experimental methods can be useful in overcoming the sample size problem. There are many military training exercises that are performed repeatedly by many units within an annual or biannual training cycle. Accumulation of training records and appropriate performance measures can provide a large sample of baseline data for comparison with the results achieved when new training devices are used, or any other training innovations are implemented. Although the present research was performed in an institutional training setting with a school course, a similar approach could be used with multiple intact units at any echelon that participate in similar training events year after year. Cook and Campbell (1979) present a large number of other quasi-experimental designs that can be used in various circumstances.

A second problem in device testing discussed by Boldovici (1987) is that the amount of training may be insufficient to affect proficiency. The training conducted in SIMNET in this research was relatively brief, and might easily have produced no measurable transfer effect. In fact, this would have been the result if only the first few classes were examined after the SIMNET training was installed in the AOB course. Since the benefit of the SIMNET training gradually increased as the instructors gained experience, the amount of training was insufficient for students trained by instructors that did not yet know how to train effectively using the device. The problem of insufficient student training in a device may often turn out to mask a more fundamental problem, i.e., insufficient instructor preparation and experience.

The importance of instructor experience in SIMNET is a clear illustration of a generic problem that may contaminate most of the training device effectiveness tests conducted by the U.S. Army. These tests are usually conducted as one-shot training events. After an brief course on the operation of the device and methods of conducting training, the test instructors are normally required to deliver the new training to the test sample without further training experience. If "learning to train" is an important factor determining training device effectiveness, and instructors need an extended period of experience to become proficient, then test results will seriously underestimate the training value of an effective device.

The important general implication of the "learning to train" effect shown in SIMNET is that the amount of instructor experience necessary to train effectively must become a high priority, critical issue examined in all future device tests. This factor must be assessed as a fundamental precondition for the validity of any estimate of training effectiveness or transfer of training to be expected under the conditions of a normal mission profile for the training device.

## Implications for Unit Training

U.S. Army unit training doctrine, as outlined in FM 25-3 and FM 25-100 (U.S. Department of the Army, 1984, 1988a), makes leaders at every level responsible for training mission-essential tasks for their unit. In most circumstances, the leader serves directly in the role of the instructor in a training event. For a collective training device like SIMNET, this training guidance has serious implications for the effectiveness of unit training. Based on the usual turnover rates for unit leaders, network simulator instructors will rarely have sufficient training experience to plan and conduct effective unit training.

Although the AOB students are not typical of unit personnel, they are relatively untrained in tactical techniques. Starting from a lower base, AOB platoons should show the benefits of training more readily than an intact platoon that is partially trained. The present results indicate that a substantial amount of experience is needed to conduct effective training in even the most basic platoon-level exercises. This will undoubtedly prove to be even more true at the higher echelons that conduct large-scale exercises on an infrequent schedule. In order to obtain the full benefits of networked simulator training, a special effort must be made to develop ways of training instructors to make them effective without much direct experience in conducting training at a particular echelon. Without superb training for the trainers, much of the utility of training units in networked simulators will be diminished.

## Conclusions

Many factors were present in the AOB Course to affect the results of training. Close examination of all the available evidence supports the following main conclusions:

1. Elementary contact exercises given early in the MTT field training were reduced in number after SIMNET and HMMWV tactical training were added to the AOB Course. The relative contribution of SIMNET and HMMWV exercises to this savings cannot be established.
2. Additional tactical training produced positive transfer of training to the performance of AOB students acting in leader positions in platoon-level MTT exercises. The transfer did not occur in the initial classes trained in SIMNET, but increased gradually in subsequent classes.
3. Improved student performance in the MTT enabled instructors to begin advanced exercises at an earlier point in the field training, and to complete a larger number of these exercises.

4. The increases in student performance and advanced training were accompanied by indications of a parallel increase in the judged quality of tactical leadership for AOB graduates. This possible trend may have been disturbed by effects of confounded variables acting on the early SIMNET-trained classes. Additional confirmation of this effect is needed.

5. Informal observations of SIMNET training suggested that the Team Chiefs gradually improve their techniques in conducting this training, particularly in the AARs, as they gained experience from training successive platoons. The improvement in SIMNET training, rather than HMMWV training, appeared to be responsible for much of the increases in performance, advanced training, and graduate quality that were obtained. This conclusion must be regarded cautiously within constraints on inference imposed by quasi-experimental results, and requires further confirmation.

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## Appendix A

### The Combined Arms Tactical Training Center and the Simulation Networking System

The Combined Arms Tactical Training Center (CATTC) houses the Simulation Networking (SIMNET) system at Fort Knox. The CATTC was known as the SIMNET Warfighting Complex before its transfer from DARPA to Army management in 1990. The CATTC has SIMNET modules representing a tank battalion and an infantry company. The modules operate interactively through a local area computer network (LAN). Each module simulates a combat vehicle, either the M1 Abrams tank, the M2 Bradley infantry fighting vehicle, or the M3 Bradley cavalry fighting vehicle.

Modules are operated by vehicle crews on simulated terrain in a manner similar to real vehicles. The modules were designed with selective fidelity to reduce costs. Functional controls and displays used in combat operations are operative, while others (such as those used only in system setup or fault diagnosis) are nonfunctional mockups. A crew uses their module to move over the battlefield, detect and shoot enemy vehicles, and communicate both within the crew and to other vehicles and organizations. Modules simulate the effects of combat damage or destruction, equipment breakdowns, and consumption of fuel and ammunition.

A tank module has adjacent driver and turret compartments that represent the crew spaces, operator station controls, instrument displays, radios, and internal communication system used by crewmen during closed hatch operations. A self-contained host microcomputer and graphics processor drives the simulation for each module. The computer (a) receives and sends data packets on the LAN, (b) processes data from control inputs, dynamic vehicle and weapon models, remote vehicle status, and the terrain data base, and (c) sends signals to instrument displays and simulated vehicle sounds to the audio system. The graphics processor combines data on the terrain, vehicle status, remote vehicle appearance, and weapon effects to compute and present visual images on displays. Crewmen can see external views of the battlefield, other vehicles, and weapon effects through eight simulated vision blocks and weapon sights. A detailed description of the components and functions provided by SIMNET vehicle modules is contained in the SIMNET Users' Guide (U.S. Army Armor School, 1989). Operation of the module controls, instruments, and displays for each crew position is described in the M1 SIMNET Operator's Guide (U.S. Army Armor School, 1987).

Activity on the module LAN is coordinated by the SIMNET Management, Command and Control (MCC) subsystem. The MCC includes a host microcomputer and operator console linked to the module LAN, and linked also to an second LAN with several microcomputers. One microcomputer is used as a control station to initialize the terrain location and condition of the vehicles

participating in an exercise, and to activate the corresponding simulator modules. Several other microcomputers placed in a simulated Tactical Operations Center (TOC) serve as Combat Support (CS) and Combat Service Support (CSS) stations operated by unit headquarters staff to provide fire support, close air support, administrative, logistic, and maintenance functions.

A Semi-Automated Force (SAFOR) station linked to the LAN permits unmanned simulated vehicles to be operated on the battlefield, either singly or in small units. The SAFOR vehicles may represent additional friendly forces, or opposing forces (OPFOR). When the SAFOR station controls a friendly force, the operator has radio communications with the TOC and other units, simulating a unit commander. When controlling OPFOR vehicles, the operator acts as an intelligent opponent, trained to portray Threat doctrine and tactics in an accurate manner.

An third LAN linked to the MCC host includes computer equipment to support exercise observation, external evaluation, and after-action review (AAR). The complete stream of data packets passed on the Ethernet LAN can be captured, stored on disk or tape media, and retrieved using the SIMNET Data Logger. The Plan View Display (PVD) presents a graphic map overview of the terrain. The PVD shows the position, movement, and firing of vehicles in real time during an exercise, or during an AAR replay of recorded exercise data. The PVD provides functions that can be used to adjust the display. For example, PVD functions allow an observer to change the scale or location of the map area, and add or remove some display features, such as map contour lines.

A Stealth Display was added to supplement the PVD several weeks after this research began. The Stealth Display has three large television monitors set side by side to provide about a 120° view of the battlefield. The point of view can be set to follow a moving vehicle, or look through the vehicle commander's vision blocks. An observer also has controls that let him move around freely, to view any area on the battlefield from any height, distance, and angle desired. The term "stealth" was applied to this capability since the observer's position is not revealed to the exercise participants under any conditions.

The SIMNET modules are located in a large open bay area within the CATTC facility. Rows of four modules are placed on both sides of a wide central aisle. CATTC staff operate the MCC control station in an central area near the front entrance of the bay. During this research, the PVD and Stealth Display were located in an small control center isolated by camouflage netting next to the MCC control station, while the simulated TOC was placed at the front on one side of the bay. A SAFOR station was placed in an row empty of modules in the middle of the bay. The organization and operation of typical SIMNET sites, and the functions provided by components of the MCC are described in the SIMNET Users' Guide (U.S. Army Armor School, 1989).

## Appendix B

### Tactical Training in the Armor Officer Basic Course

At the time of this research, the Armor Officer Basic (AOB) course was structured to give classroom instruction on platoon tactics during eight days near the end of the course, just before ten days of Mounted Tactical Training (MTT) in the field. The main topics that are formally recognized in the AOB training schedules are listed in Table B-1.

Instructional sequence. First, more than a day of lectures covered (a) armor and cavalry missions and organizations, (b) operations orders and troop leading procedures, (c) quartering party activities and road marches, and (d) formations, drills, and techniques of movement. Second, about two and one-half days of classes were on cavalry topics such as reconnaissance and security operations. A one-hour written test ended this part of the course. Starting with the second SIMNET-trained class, the student officers spent more than two added days of training in the field, employing HMMWV vehicles to simulate the basic armor and cavalry tactical techniques that had been introduced up to that point. This MTT-like training was confounded with the SIMNET training as a second major change in training conditions.

The next four days were devoted to instruction on offense and defense fundamentals. On each day, lectures in the morning were followed in the afternoon by a practical exercise period using terrain boards. In groups of eight, the students used miniature tank models on a terrain board to represent platoons, demonstrating C<sup>3</sup> and other techniques that were covered in the preceding lectures. In this training, the students went through much of FM 17-15 page by page to practice in turn each tactical procedure for the tank platoon.

The Performance Examination was administered the next day. The examination was composed of a written portion, taking 30 to 45 minutes for the class as a whole, and a terrain board portion that consumed the remainder of the day. In the latter portion, students were tested individually for 15 to 20 minutes, reacting to selected tactical situations by demonstrating appropriate communications procedures and platoon actions on the terrain board. The few students who failed the exam were given remedial instruction and retested after the MTT at the end of the course in baseline classes.

After the baseline classes, SIMNET training was inserted between the Performance Examination and the MTT training. The two days of SIMNET training were separated by a two-day weekend in four classes. In all SIMNET-trained classes, students who failed the exam were given remedial instruction and retests on the morning after the SIMNET training, but before moving to the field to begin MTT training that afternoon. For all classes, the

**Table B-1**

**Typical Tactical Training Schedules in the AOB Course**

Course Subject	Hours	Week/Day	
		Start	End
<b>Baseline Classes<sup>a</sup></b>			
Basic Armor Techniques	10	14/2.5	14/3.5
Cavalry Operations and Exam	28	14/3.5	15/1
Mounted Tactical Training-HMMWV	0	----	----
Offense and Defense Operations	36	15/1.5	15/4.5
Commander's Time	1	15/1.5	15/1.5
Performance Examination	11	15/5.5	15/5.5
Mounted Tactical Training-SIMNET	0	----	----
Mounted Tactical Training-Armor	219	16/2	17/4
Examination Retest and Review	11	18/1	18/1
<b>Initial SIMNET Classes<sup>b</sup></b>			
Basic Armor Techniques	10	14/3	14/4
Cavalry Operations and Exam	28	14/4	15/1
Mounted Tactical Training-HMMWV	30	15/1	15/2
Offense and Defense Operations	36	15/3.5	16/2.5
Commander's Time	2	16/2.5	16/2.5
Performance Examination	7	16/3.5	16/3.5
Mounted Tactical Training-SIMNET	18	16/4	16/5
Examination Retest and Review	7	16/6	16/6
Mounted Tactical Training-Armor	219	17/1	18/2.5
<b>Later SIMNET Classes<sup>c</sup></b>			
Basic Armor Techniques	10	13/4	13/5
Cavalry Operations and Exam	28	13/5	14/2
Mounted Tactical Training-HMMWV	30	14/3	14/4
Offense and Defense Operations	36	14/5	15/3
Commander's Time	2	15/3	15/3
Performance Examination	7	15/4	15/4
Mounted Tactical Training-SIMNET	18	15/5	16/1
Examination Retest and Review	7	15/6	15/6
Mounted Tactical Training-Armor	219	16/2	17/5

**Note.** Values are medians for hours and week/day numbers. These schedules differ from current ones owing to later course changes.

<sup>a</sup>Last six classes without SIMNET training. <sup>b</sup>Six classes. Unlike the last five classes in this group, the first class omitted HMMWV training and a 17-day year-end holiday. <sup>c</sup>Five classes.

ten days of MTT field exercise training occurred on consecutive days, without any days off during this period.

Training schedules. The training schedules that 18 AOB classes followed from mid-1988 to mid-1989 were available for examination. Table B-1 presents a summary of hours and days in the tactics portion of these schedules covering weeks 14 through 18 of the AOB Course. Other training on maintenance and gunnery during this period is not shown in Table B-1. The hours are similar for most AOB classes, with only one or two classes deviating slightly for some course subjects. The starting and ending days were found to vary more because of the occurrence of holidays for some classes and not others. Few differences appear between baseline and SIMNET-trained classes. SIMNET training added 18 hours over two days, field training using the HMMWV took a continuous period of 30 hours, and one extra hour was given to Commander's Time. Four hours were taken both from the Performance Exam and from the Exam Retest and Review.

After the first class given SIMNET training but no HMMWV training, the SIMNET-trained classes had a net increase of 41 schedule hours spread over about 3.5 days. The course was initially extended by five training days for classes that were interrupted by Christmas/New Year holidays. The holiday period appeared to be responsible for two of the days, leaving about three days of additional training. After these classes the extension was reduced to one day, with the time being made up in earlier parts of the course.

One Reserve Component (RC) class made up of officers from reserve units is omitted from Table B-1. The AOB course at the Armor School is eight weeks for RC officers, who complete a portion of the course by correspondence. The RC class in this sample had only one platoon. They received about one-half of the normal hours in tactical subjects, but had the full schedule of MTT training. Although the RC class came after HMMWV and SIMNET training were added to the course, the schedule for this class omitted both of these training events.

## Appendix C

### Armor School Evaluation Forms

Table C-1

Items Common to the 1987-1988 Editions of ATSB-CS Form 1447 and Used to Measure AOB Student Performance in Field Exercises

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#### FIELD EVALUATION - ARMOR PLATOON TACTICS

##### PART I - TACTICAL SKILLS

##### 1. PLANNING-USING & TROOP LEADING PROCEDURES

- A. CONDUCT PLANNING PROCESS USING METT
- B. ISSUE CLEAR, CONCISE AND DETAILED ORDERS (WARNING ORDER, OPORD, ETC)
- C. ASSIGN DUTIES AND SUPERVISES SUBORDINATES

##### 2. MOVEMENT AND CONTROL

- A. BEGINS MOVE IN PROPER FORMATION AND ON TIME
- B. CROSSES LD/SP IN PROPER FORMATION AND ON TIME
- C. MAINTAINS PLT/TEAM INTEGRITY AND DISPERSION
- D. LEADER BEST LOCATED TO CONTROL AND IS CONTROLLING
- E. UTILIZES PROPER TECHNIQUES OF MOVEMENT CONSISTENT WITH

METT

##### 3. CONDUCT OF OPERATION

- A. MAINTAINS SECURITY (360 DEGREES, COVER/CONCEAL, HIDE/HULL DOWN, OVERWATCH)
  - B. TIMELY AND COMPLETE REPORTS
  - C. REPORTS CONTROL MEASURES
  - D. EMPLOYMENT OF INDIRECT AND DIRECT FIRES
  - E. REACTION TO CONTACT (REFER TO MISSION AND OPORD)
  - F. FLEXIBLE TO CHANGING SITUATIONS (ISSUE FRAGO'S ETC)
  - G. KEEPS THE TRP/CO CDR INFORMED
  - H. ACCOMPLISHES MISSION
  - I. OCCUPATION OF BATTLE POSITION
- 

**Note.** Different rating categories were used in the two editions.

1 Dec 87 Edition:	O = OUTSTANDING	A = AVERAGE
	B/A = BELOW AVERAGE	N/A = NOT APPLICABLE
1 Dec 88 Edition:	O = OUTSTANDING	S = SATISFACTORY
	U = UNSATISFACTORY	N/A = NOT APPLICABLE

Table C-2

Items Common to the 1987-1988 Editions of ATSB-CS Form 1445 and Used to Measure Quality of Tactical Leadership for AOB Graduates

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COMPREHENSIVE STUDENT EVALUATION - AOB TACTICS PHASE

PART II: 1 Dec 87 Edition

1. IS THIS OFFICER'S JUDGEMENT RELIABLE?
2. WAS THIS OFFICER INNOVATIVE?
3. DID THIS OFFICER SEEK RESPONSIBILITY?
4. DID THIS OFFICER ACCEPT RESPONSIBILITY FOR HIS ACTIONS?
5. DID THIS OFFICER OPERATE EFFECTIVELY UNDER STRESS?
6. DID THIS OFFICER DEMONSTRATE AN INTEREST IN PARTICIPATING AND LEARNING TACTICS BEYOND THAT REQUIRED IN HIS ASSIGNED LEADERSHIP POSITION?
7. WAS THIS OFFICER SELF MOTIVATED AND DID HE SHOW INITIATIVE IN ALL ASPECTS OF HIS PERFORMANCE?
8. DOES THIS OFFICER MAINTAIN EFFECTIVE COMMUNICATION AND COOPERATION WITH HIS JUNIORS, SENIORS, AND PEERS.
9. DID THIS OFFICER DEMONSTRATE TECHNICAL COMPETENCE THROUGH ALL PHASES OF THE MTT?
10. DID THIS OFFICER DEMONSTRATE AN UNDERSTANDING OF THE FUNDAMENTALS OF TACTICS AND THE PRINCIPLES OF WAR WHEN LEADING HIS PLATOON OR SECTION?

PART II: 1 Dec 88 Edition

1. WAS THIS OFFICER'S JUDGEMENT RELIABLE (DECISION MAKING)?
2. WAS THIS OFFICER INNOVATIVE IN HIS PLANNING/EXECUTION OF MISSIONS?
4. DID THIS OFFICER SEEK AND ACCEPT RESPONSIBILITY FOR HIS ACTIONS (PROF ETHICS)?<sup>a</sup>
5. DID THIS OFFICER EFFECTIVELY OPERATE UNDER STRESSFUL CONDITIONS?
6. DID THIS OFFICER DEMONSTRATE AN INTEREST IN PARTICIPATING AND LEARNING TACTICS BEYOND THAT REQUIRED IN HIS LEADERSHIP POSITION?
7. DID THIS OFFICER DISPLAY INITIATIVE IN ALL ASPECTS OF HIS PERFORMANCE (POSITIVE ATTITUDE)?
8. DID THIS OFFICER MAINTAIN EFFECTIVE COMMUNICATION AND COOPERATION WITH HIS JUNIORS, SENIORS, AND PEERS.
9. DID THIS OFFICER DEMONSTRATE TECHNICAL COMPETENCE?
11. DID THIS OFFICER DEMONSTRATE AN UNDERSTANDING OF THE FUNDAMENTALS OF TACTICS AND THE PRINCIPLES OF WAR WHEN LEADING HIS PLATOON OR SECTION?

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<sup>a</sup>Counted as two items.

Appendix D

Analysis of Variance Tables

Table D-1

Analyses of Variance on Counts of Field Evaluations

Source of Variance	df	SS	MS	F	p
<b>Movement Exercises</b>					
Trend	1	88.29117	88.291	36.605	.000
Team Chiefs <sup>a</sup>	12	63.42239	5.285	2.191	.021
Residual	71	171.27467	2.412		
<b>Contact Exercises</b>					
Level	1	12.44993	12.450	5.000	.029
Team Chiefs <sup>a</sup>	12	244.82345	20.402	8.194	.000
Residual	71	176.77368	2.490		
<b>Elementary Exercises</b>					
Trend + Level	2	134.58051	67.290	22.107	.000
Team Chiefs <sup>a</sup> + Size	13	381.04302	29.311	9.629	.000
Residual	69	210.02353	3.044		
<b>Advanced Exercises</b>					
Trend + Level	2	292.35746	146.17873	16.030	.000
Team Chiefs <sup>a</sup> + Size	13	987.54924	75.96533	8.331	.000
Residual	69	629.19915	9.11883		
<b>Total Evaluations per Man</b>					
Trends	2	.44121	.22060	6.550	.002
Team Chiefs <sup>a</sup> + Size	13	2.60251	.20019	5.944	.000
Residual	69	2.32381	.03368		

**Note.** Two of the 87 platoons had many missing records, and were therefore deleted from these analyses.

<sup>a</sup>Three temporary Team Chiefs each trained only one platoon and were combined together for analysis.

Table D-2

Analyses of Variance on Field Evaluation Ratings

Source of Variance	df	SS	MS	F	p
First Rated Exercise					
Regression <sup>a</sup>	6	18122.35891	3020.393	5.115	.000
Team Chiefs <sup>b</sup>	12	91581.94960	7631.829	12.678	.000
Residual	1263	745771.59083	590.476		
Second Rated Exercise					
Regression <sup>c</sup>	2	19347.24888	9673.624	10.808	.000
First Rating	1	104074.74024	104074.74	116.280	.000
Team Chiefs <sup>b</sup>	12	186408.86248	11534.072	15.688	.000
Residual	1266	1133109.22899	895.031		

<sup>a</sup>Includes effects of Phase, Week, Position, and Day. <sup>b</sup>Three Team Chiefs each trained only one or two platoons and were combined for analysis. <sup>c</sup>Includes effects of Phase x Position and Day.

Table D-3

Analyses of Variance on Comprehensive Student Evaluation Ratings

Source of Variance	df	SS	MS	F	p
Percentage of Students with Perfect Ratings <sup>a</sup>					
Regression <sup>b</sup>	4	10166.33483	2541.584	1.327	.266
Team Chiefs <sup>c</sup>	14	115424.75662	8244.625	4.305	.000
Residual	91	174290.63511	1915.282		
Percentage of Ratings in the Highest ("Yes") Category <sup>a</sup>					
Regression <sup>b</sup>	4	2715.61035	678.903	1.759	.144
Team Chiefs <sup>c</sup>	14	28788.11181	2056.112	5.328	.000
Residual	91	35116.86477	385.900		

<sup>a</sup>Transformed to angles in radians by the inverse sine function. <sup>b</sup>Includes level, linear and quadratic trend in the SIMNET phase, and linear trend in the Baseline phase. <sup>c</sup>Two Team Chiefs each trained only one platoon and were combined together for analysis.

## Appendix E

### Threats to Valid Inferences

Campbell & Stanley (1966) and Cook & Campbell (1979) identified many factors that threaten the validity of inferences in quasi-experimental research. These factors are categories of variables that may confound the comparison between a treatment and a control condition. Variables representing several kinds of factors may affect the comparison between the baseline and SIMNET groups. The nature of the factors and the effects of variables identified in this research are summarized below.

#### Definition and Examples of Factors

The factor of history refers to unique or aperiodic events coincident in time with the application of the treatment that may affect the dependent variables. Any changes in the AOB Course that were made at the same time that SIMNET and HMMWV training began are perfectly confounded with the change in training conditions. Effects of such confounded changes might add to or subtract from the observed effects, and may be difficult or impossible to separate from the training effects. One variable of this type was the reduction in examination review time used to compensate for time given to the added training. Other events occurring before or after the change may also produce effects that obscure the comparison between baseline and SIMNET classes.

Regular cyclical changes are termed seasonal factors, i.e., annual variations associated with the seasons. These include typical weather conditions, availability of training resources, or class sizes that coincide with the change in training and contribute to observed differences between training conditions. Precipitation affects visibility and the trafficability of terrain, altering the difficulty of tactical missions practiced in the field. Overlapping training support requirements in the Armor School at some times of year may limit the use of some equipment or facilities by AOB classes. Large or small class size at some periods can lead to variations in the number of crews organized in AOB student platoons, requiring modified techniques to execute doctrinal tactics.

The factor of maturation may operate to affect instructors, training conditions, or equipment. Maturation refers to long-term trends associated with the passage of time and any other variables that change in a manner correlated with the passage of time. Instructors gain experience, and their job satisfaction or motivation may increase or decrease as they train a series of classes. A stable average for these variables might be expected to be maintained in the baseline condition, if the rate of turnover in the instructional staff remains stable. However, instructors necessarily begin with relatively little SIMNET experience, and increase their experience in successive classes

as they use SIMNET for training. Instructors may be expected to change their attitudes for or against using SIMNET based on subjective impressions of difficulties and benefits derived from SIMNET training. Traditional training practices may evolve gradually in either the baseline or SIMNET conditions as the collective wisdom of the instructional staff and course managers changes over time. Continuing modifications to the SIMNET equipment also can affect how it is used, and the training results obtained. Progressive wear on the tanks used in field training might detract from the effectiveness of that training. Trends in the level of tank maintenance that start or stop when the training conditions changed could hamper or facilitate field training by changing the frequency of vehicle breakdowns.

The instrumentation factor involves changes in the procedures of measurement or the calibration of scales. Changes in forms used to evaluate students, or changes in the standards or biases applied by the evaluators, may alter the level or trend of measured values and enhance or reduce the observed training effects. Since the major change in forms used with the present sample of AOB classes was made in the middle of the baseline phase at a different time from the change in training, these instrumentation effects may be disentangled from the training effect. However, some minor changes in forms also were made near the time of the first SIMNET-trained class and may seriously complicate the interpretation of training effects.

Selection may occur for both students and instructors. The students in the baseline and SIMNET classes may be dissimilar in characteristics such as ability, education, or experience that influence their learning and performance in the AOB Course. Turnover in instructors may systematically increase or decrease their ability as a group to train students effectively in SIMNET or field exercises. Since the instructors serve as evaluators, turnover also may contribute to an instrumentation effect.

The mortality factor involves differential attrition of students or data in the baseline or SIMNET groups. Since entering students are highly selected, the number who fail to graduate from AOB or are recycled to a later class is very small, and is not expected to affect the results. However, loss of data may be more serious, since the oldest class record files tend to be less complete than files for more recent classes.

Ambiguity in causal direction may result indirectly from effects of any the factors above, or from feedback from the SIMNET effects. Instructors may incorrectly perceive spurious changes from any factor to be the result of SIMNET or HMMWV training, adjust any part of the training in an attempt to make improvements, and thereby change the observed effect. Similarly, feedback from the instructors' perception of real SIMNET or HMMWV effects on student performance may in turn result in training changes that amplify or attenuate the original effects.

## Effects of Confounded Variables

Historical factors. The added HMMWV training was the most important variable confounded with the SIMNET training. The HMMWV training was not observed, and the student learning resulting from that training was not independently measured. Only the first SIMNET-trained class provided a control condition to indicate what impact the HMMWV training had when it was given to the second and later classes. The apparent differences among these classes in field performance in Figure 6 suggests that the HMMWV training at first had a negative transfer effect. Such an interpretation is not very credible, since the performance of the first HMMWV-trained platoons was not unusually low compared with other baseline platoons. Consideration of variables discussed in later sections suggests that the actual result of HMMWV training was obscured by other effects.

Other reasonable interpretations of the difference between the first two classes trained with SIMNET are implied by atypical conditions that might be associated with the first class. The first class may have been exceptionally good, or was perceived to be so by some of the instructors. The average performance ratings were relatively high for one platoon in this class. The measures of graduate quality in Figures 10 and 11 tended to be high in this class as well. Two other conditions also were unique. First, as the initial SIMNET-trained class, expectations about the benefits of SIMNET may have acted as a self-fulfilling prophecy to alter perceptions of performance and graduate quality and thereby producing biased ratings. Second, this class also successfully participated in a tryout of special gunnery range training, adding a difficult Table VIII exercise to the training usually conducted in the AOB Course. While direct transfer from the gunnery training to tactical training is implausible, high performance in this exercise may have added to perceptions of the leadership qualities possessed by these students, and contributed a halo effect to their tactical ratings. There is no evidence to discriminate between these two explanations, and both factors may have combined to artificially elevate the results for this class.

Other platoons with unique histories were three RC platoons at weeks 26 and 30 in the baseline phase, and one at week 79 in the SIMNET phase. All these platoons received a short version of the AOB Course, but an MTT of the normal length. One of the baseline RC platoons had relatively low performance ratings. Another baseline RC platoon was discarded from the analysis of exercise counts since the records were apparently missing for two crews, resulting in deviant counts. Other results for the baseline RC platoons were entirely in line with normal platoons. The RC platoon in the SIMNET phase was not trained in SIMNET, and showed performance near the baseline level as expected. This platoon was kept as a SIMNET platoon to avoid complicating the analyses. It helped to estimate the regression parameter for its Team Chief, and also offset an unusually high value for one

platoon near that time. The major trends in the results were little affected by the inclusion of the RC platoons.

The addition of the stealth display to the SIMNET system probably had some beneficial effect on the training from the fourth SIMNET-trained class onward. It allowed at least some of the Team Chiefs at any one time to control the exercises more effectively for training purposes. Effects from use of this display along with the PVD may have amplified effects of the instructor experience in SIMNET, a maturational factor to be discussed at a later point. These displays helped the Team Chiefs to evaluate actions of the tank crews and the student leaders more fully and accurately in some of the exercises. The displays may have facilitated AARs along with other improvements in training that were observed. However, the possible benefits of the displays cannot be separately quantified.

Before and during the period occupied by the AOB classes that were sampled, limited funding placed constant pressure on the Armor School to reduce resources used in field training, especially in terms of tank operating miles and fuel. This historical factor had a major effect on the number of movement exercises, indexed by the number of student evaluations. The managers responsible for the AOB Course reported that they chose to accomplish a share of the required cuts by reducing exercises that required a relatively large expenditure of resources. The declining trend in movement exercises before the addition of the SIMNET and HMMWV training reflects the effort made to conserve resources. Limits on resources also motivated the substitution of additional simulator and wheeled vehicle training for the reduced on-tank training.

Seasonal factors. Both the position of holidays within the AOB Course and weather conditions experienced during the MTT are seasonal factors that may have affected the results. The first class trained in SIMNET completed the MTT and the course just before the Christmas/New Year holiday period. The next class had an 18 day layoff for the holiday during their tactical training. The layoff followed their Performance Examination, and the course resumed with the SIMNET training. This class may not have retained all of the prerequisite knowledge and skills needed to make the best progress in SIMNET, resulting in poorer performance in the field. Looking back to the first baseline class in 1988 shown in Figure 6, the field performance for the two platoons in that class was similar to the average of other baseline platoons. This evidence suggests that the holiday layoff has no direct effect on field performance, and is unlikely to have affected the SIMNET training as well.

The third class had a similar vacation after their tank gunnery, land navigation, and artillery classes. In this case, tactical training started immediately after the holiday. Considering the difficulty of navigation on SIMNET terrain, this

class may have been hindered somewhat by forgetting some knowledge and skills in this area. For the next three classes, the course was interrupted at earlier points that should not have affected either their learning in SIMNET, nor their later performance in the MTT. The course was not interrupted by a lengthy holiday in other classes. Since the platoons in classes early in 1988 all cluster near the baseline (but for one abnormally high platoon), the comparable classes in 1989 also were probably not affected by the holiday interruption.

Little information is available on weather effects. Without field observations or reports from the instructors, effects on specific classes are unknown. Heavy rain is the most serious potential problem, making it difficult to maneuver tanks over muddy terrain. The effects of rain on the ground conditions can persist for several days, or even through the whole MTT. In that case, the effect might result in a reduction in the number of exercises, especially advanced ones, that could be completed in the available time. Fog or snow reduce visibility, but this condition is apt to interfere with the conduct of coordinated platoon movement or enemy engagement for relatively short intervals of time. Usually, the TCI or Team Chief would be expected to take the prevailing conditions into consideration, so that the effect on field evaluations would be minimal. However, in some instances, increased difficulty of exercise conditions might lead to a degradation of student performance, even for actions not directly related to the weather conditions. Weather was not anticipated to have major consistent influences on the measures of performance or graduate quality, and no systematic study was made of this factor.

Maturational factors. The primary maturational factors of concern in this research have to do with instructor experience and training conditions. The direct effects of instructor experience with training in SIMNET or using the HMMWV are discussed in this section. General effects in relation to instructor turnover are examined in a later section on selection effects. No general progressive improvement or deterioration of the SIMNET equipment or its operation by the CATTC staff was observed during the SIMNET phase of the research, so an effect from this source was presumed to be nonexistent. No information on vehicle maintenance was obtained from hearsay to indicate any unusual trends, but this factor was not documented.

In SIMNET, some changes were observed as the instructors gained experience. Some small revisions were made in the mission scenarios and OPORDS to make the exercises easier to control, but these changes did not seem to have a major effect on their training effectiveness. The Team Chiefs increased the information provided to the students on methods of land navigation useful in SIMNET. This reduced the incidence of major navigational errors somewhat, and reduced the frequency of exercises aborted by navigational problems. However, students

continued to have difficulty in maintaining their axis of advance and in reporting their position accurately throughout the SIMNET training that was observed.

The main changes were observed in the AARs. Team Chiefs increasingly used the SIMNET PVD and Stealth Display when they were available to evaluate performance, noting important events for discussion in the AAR. The Team Chiefs became more skillful in directing attention to the critical events that determined mission success in the exercises. They allowed the student leaders less time to dwell on incidental events that were relatively unimportant. They increased the focus on typical lessons to be learned that could be generalized to tactical operations with real tanks. They more frequently pointed out specific events that might be fortuitous occurrences or just artifacts of SIMNET, but that were unreliable guides to effective tactics under more usual conditions. They especially increased their emphasis on the effective use of time in planning and troop leading, and on executing effective techniques of command, control, and communication (C<sup>3</sup>).

Changes in the AARs seemed to have some impact on the gains in student leader and platoon performance that were exhibited in the sequence of exercises conducted in SIMNET. The subjective impressions of both ARI observers agreed that the general level of performance improved more in later classes than earlier ones, although the differences were not dramatic. However, specific areas of improvement were inconsistent from exercise to exercise, from platoon to platoon, and from class to class.

While the Team Chiefs were familiar with conducting similar exercises and AARs in the field, these instructors appeared to have adapted their training to the peculiarities of SIMNET and the exercises conducted in that context. The Team Chiefs appeared to recognize specific kinds of deficiencies in the students' performance and modified their instruction to increase its effectiveness in meeting the student's needs. Several Team Chiefs reported subjective impressions confirming this effect. They felt that they had learned to train better using SIMNET as their experience increased. The ARI observations and Team Chief reports lend credence to the second transfer hypothesis rather than the first. The conclusion is that the SIMNET training became more effective in later classes, and that this change was responsible for a progressive increase in transfer of training.

The instructors responsible for the HMMWV training may have experienced a similar "learning to train" effect. Neither training observations nor reports from these instructors were obtained to cast light on this issue. The HMMWV training concentrated on basic techniques of C<sup>3</sup> and platoon movement, and cavalry operations involving reconnaissance and security. Although the HMMWV training was conducted with light wheeled vehicles, this training probably required less modification of

the instructors' normal field training practices than the changes necessary for effective use of SIMNET. In addition, the ARI observers did not notice any trend toward improved initial performance in the road march and movement exercises conducted in SIMNET. This observation suggests that whatever benefit the HMMWV training might have contributed, it did not change markedly for successive SIMNET trained classes. Furthermore, the number of elementary field exercises did not show a progressively decreasing trend. Better HMMWV training would be expected to produce transfer allowing some further savings in this type of training. The data are more consistent with an initial and roughly constant transfer effect from the HMMWV training, producing the observed savings in number of contact exercises. The reduction in contact exercises shown in Figure 3 appeared in the first class given the HMMWV training. This reduction tended to revert toward the baseline level in some later platoons, and did not continue to decrease. Based on this evidence, the tentative conclusion is that the major portion of the obtained increase in transfer, additional advanced training, and possible improvements in graduate quality, all should be credited to the improved training received by the later SIMNET-trained classes.

Instrumentation factors. Changes in the terms applied to the middle and lower category of the rating scale were made on the field evaluation form, but no change was made in the computation of ratings derived from the form. The form was changed for the first class given MTT training in 1989, which was the second class given SIMNET training and the first class given HMMWV training. If "Satisfactory" represents a higher rating to the TCIs and Team Chiefs than "Average" the change in category labels shifted upward the subjective scale values corresponding to the categories. On the new scale, ratings would tend to be placed in lower categories reducing the computed average rating. This was the effect observed in going from the first to the second and third SIMNET-trained classes. Thus the rating scale change was an additional factor possibly responsible for the initial pattern of field evaluation results.

A direct comparison of scale values for "Satisfactory" and "Average" is not available. However, indirect evidence in Dyer, Matthews, Wright, Yudowitch, and Nystrom (1976) suggests that the first of these terms tends to be above the scale neutral point, and the second term tends to be near the neutral point, meeting the condition required to shift the measuring scale. Given a real and permanent shift effect, support for the second transfer hypothesis is strengthened. With the first exercise ratings in the SIMNET phase of Figure 6 raised by a constant compensating for the change in scale, the intercept of the linear regression would remain near the baseline level, but increase in slope.

The comprehensive student evaluation form was changed during the baseline period, entirely separate in time from the change in training conditions. Two subcategories that divided the middle

segment of the scale ("Needs Improvement") were deleted together with the labels ("Some" and "Much") for these subcategories. Since the "Much" response had been used very infrequently, the elimination of this category by itself was expected to have little effect. On the other hand, "Needs improvement" seems to be a lower rating than the original "Needs some improvement". This change could be expected to reduce the use of the middle category and increase the level of the average ratings. The regression analyses showed a small effect of this kind that was not significant. Besides the scale change, several items were added to the form. While the new items did not contribute to the measure of graduate quality used in the research, these items did change the context for the ratings on the other items. What difference the context might have made, if any, is unknown. Neither the change in scale or the added items can be related to trends in the quality measures during the later SIMNET phase.

A large number of items in the field evaluations were classified as N/A, but this is regarded as an inherent weighting of the behavior sampled in the field exercises rather than a source of bias. Changes in the frequency of N/A ratings for particular items may represent either a difference in field exercise conditions that can be considered to be part of the effect of the change in training conditions from the baseline phase to the SIMNET phase, or an instrumentation factor. Without observing exercises in the field, these possibilities cannot be distinguished. The distributions of N/A ratings over field evaluation items were not examined. Items given N/A ratings in the comprehensive student evaluations rarely appeared on these forms, and were with other alternatives to the Y response.

A central tendency bias was observed in the field exercise rating, since the proportion of items given average ratings was very high. This bias makes the ratings rather insensitive to performance differences, as higher or lower ratings are only given for very good or very poor performance. The ratings of leadership quality were subject to a ceiling effect because a great majority of students were given the highest rating for most items. This leaves little room at the top of the scale to show any improvement in graduate quality. Both of these habitual rating tendencies reduced the magnitude of the measurable effects. Thus, the degree of transfer of training and the improvement in graduate quality are likely to be underestimated.

One other instrumentation factor that may have affected the comprehensive student evaluations is a maturation-like long term trend in rating standards. The baseline data for the graduate quality measures showed a declining trend, statistically nonsignificant, that suggests that the standards may have been gradually increasing over time. If this trend was real and continued, it subtracted from the magnitude of the positive transfer effect obtained in the SIMNET phase. A similar trend

was not observed in the field evaluation data, and the transfer seen in field performance was probably unaffected.

One further possibility must be considered. The SIMNET training introduced into the AOB Course gave the TCIs and Team Chiefs a different situation in which to observe student performance and leadership. This novel experience may itself have affected their rating standards or biases. If such an effect was not merely an immediate, one-time change, but developed gradually over time, the SIMNET training could have started a new trend of increasing ratings that could be mistaken for positive transfer effects like those obtained. While this possibility cannot be completely discounted, it seems unlikely that similar changes would occur for both the specific field evaluation ratings and the more general student evaluation ratings. Furthermore, the performance exhibited in the SIMNET exercises should not have made the instructors more lenient in their evaluations without any real improvement in field performance or in the student's qualities of leadership. Nevertheless, the assumption that there was no training-instrumentation interaction of this kind is a critical condition underpinning the conclusion that positive transfer occurred.

Selective factors. The composition of the classes changed substantially across the three phases of this research. Academy graduates declined in number and were almost not represented in the SIMNET-trained group, while the proportion of ROTC graduates increased, constituting a large majority of the AOB students with SIMNET training. An increase in average age, and an increase in the proportion of students reporting some prior service appeared to be associated with that trend. The age difference was not large enough to be expected to effect any of the dependent variables through some age-related maturational process.

An assumption that academy graduates can be expected to be somewhat superior in the general leadership characteristics that make up the measures of graduate quality is not unreasonable. Given this assumption, the decline in proportion of academy graduates may be related to the small (and not significant) declining trend in graduate quality observed in the baseline platoons. This factor could not contribute to a further decline in the SIMNET phase because the number of academy graduates remaining in that phase was too small. However, this factor may have slightly reduced the overall level estimated in that phase, preventing a significant increase from being obtained in the analyses of the measures of graduate quality. If real, a difference in prior service would be assumed to have an opposite effect to some degree.

Similar baseline trends were not observed for the field evaluation ratings, and prior service might be assumed to be a more important factor affecting the performance of leader tasks.

Some direct experience or training related to such tasks might have been obtained during such service. The missing data for this item (see the next section) and the lack of data on time and type of service make any firm inferences very difficult in this case. The most likely effect of prior service was to add a bit to the level of performance in the SIMNET platoons. Those reporting some service differed by less than 10% for the two phases involved in the comparison of field evaluation ratings. Therefore, this variable probably did not have a major effect.

The turnover in Team Chiefs showed a tendency toward replacing officers with NCOs in the time period examined here. In the baseline phase with the old Form 1445, four officers and two NCOs acted as Team Chiefs. After the tenth week, one NCO replaced an officer. After the 35th week, one officer and two NCOs replaced an officer and an NCO. After the 55th week, an officer replaced an officer. After the 70th week, three NCOs replaced an officer and two NCOs. This left a net of two officers and five NCOs acting as Team Chiefs. Although the NCOs that became Team Chiefs were new to that job, all had many months experience as Assistant Team Chiefs. Inspection of the Team Chief parameters estimated in the regression analyses did not indicate any tendency for officers as a group to have more or less lenient standards in rating than the NCOs. The ratings given by new Team Chiefs, whether officer or NCO, did not show systematic differences or biases more than those characteristic of other Team Chiefs serving at the time. Furthermore, new Team Chiefs did not show systematic changes in ratings across the first few platoons they trained. Their ratings did not increase, indicating that they were becoming more lenient or were learning how to train better, nor did their ratings decrease, suggesting that their standards became more stringent as they gained experience. The upswing in the graduate quality ratings toward the end cannot be attributed to the NCO Team Chiefs starting near that time. The possible influence of this factor on the results should be discounted entirely.

One selective factor that was probably at work in the MTT training was indicated by position differences in the first field evaluation ratings. The Team Chiefs seem to select some relatively poor students for additional platoon leader practice, while reserving some superior students to serve as platoon leaders for the first time in the company-level exercises conducted at the end of the MTT. Students having these unusual position sequences are few in number and the effects were small. However, this tendency might have operated in the SIMNET or HMMWV training as well, producing greater gains for the poorer students and enhancing to some degree the overall level of transfer of training that was obtained. The lack of interaction effects involving the first rated position indicates that the Team Chiefs did not make a large change in their selection bias after the additional training was introduced into the course.

Missing data. For most of the student characteristics, the numbers of missing values were too small to produce any serious distortion in the main differences in group composition that were demonstrated. The main exception is that many students did not respond to the item on prior service, and the remaining data for this variable may not be representative of the actual group differences.

Missing field evaluations necessarily introduce a negative bias into counts of the number of evaluations. Except for two platoons that seemed to be missing one or more crews and were deleted from the analyses of evaluation numbers, the number of missing records could not be determined with any accuracy. However, the suspicious cases were few in number and widely scattered, with a slightly greater tendency to be in the earliest classes examined. The main obvious trends in the data cannot have been much affected by the missing records, but precise estimates of slopes and intercepts are underestimated.

Comparisons of field evaluation ratings for students with one missing record to students with complete rating data showed that the estimates of average ratings were not seriously affected by the missing data. Comprehensive student evaluations were missing for very few students, and virtually no bias can be associated with this loss of data.

Causal direction. One major instance of causal ambiguity has already been mentioned. While changes in amount of field training might be expected to cause changes in performance, various bits of evidence suggest that performance changes resulted in changes in field training practices. Other feedback effects have not been identified.