Research Report 1417

Using the Tank Gunnery and Missle Tracking System (TGMTS) for Measuring Tank Gunnery Performance

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The Tank Gunnery and Missile Tracking System (TGMTS) was evaluated as a device for measuring tank gunnery performance. To enhance its performance assessment capabilities, the TGMTS was paired with a microcomputer. The computer-augmented TGMTS was used in assessing the performance of 18 M60A3 tank commander-gunner pairs on 27 gunnery engagements. The computer-augmented TGMTS arrangement permitted precise measurement of tank commander and gunner behaviors in engaging realistic threat targets. Potential users for (Continued)

ARI Research Report 1417

20. (Continued)

the TGMTS in assessing gunner performance are discussed including gunnery qualification, personnel assignment, diagnostic testing, and evaluation of gunnery training programs.

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FOREWORD

The Army Research Institute has encouraged the use of simulation in place of actual equipment to reduce training costs. Recent advances in technology have spawned the development of high-fidelity, low-cost devices for simulating a variety of weapon systems. The Tank Gunnery and Missile Tracking System (TGMTS) is a high-fidelity simulator designed to improve the gunnery skills of tank commanders and gunners. The TGMTS is appended to the tank and fires a laser beam at targets that are rear projected onto a movie screen.

The present research was conducted as part of the Army Research Institute's continuing support of the Training and Doctrine Command and the armor community. It investigates the potential of the TGMTS to measure gunnery performance of tank commander-gunner pairs. To enhance its performance measurement capabilities, the TGMTS is paired with a microcomputer in a computer-augmented TGMTS arrangement. The computer-augmented TGMTS proved successful in measuring performance of tank commander-gunner pairs. This research demonstrates the potential for utilizing armor simulators to measure gunnery performance.

EDGAR M. JOHNSON
Technical Director

USING THE TANK GUNNERY AND MISSILE TRACKING SYSTEM (TGMTS)
FOR MEASURING TANK GUNNERY PERFORMANCE

EXECUTIVE SUMMARY

Requirement:

The Army is continually measuring the performance of its soldiers to ensure that they are ready for combat. Tank gunnery has proven one of the more difficult areas to obtain efficient and reliable measures of individual performance. Present methods of measuring gunnery performance are either expensive and difficult to administer (e.g., Table VIII), or else they rely on paper and pencil tests that may not adequately measure gunnery skill. Gunnery simulators may provide the efficient and reliable measures of gunnery performance that the Army needs.

Procedure:

The TGMTS was augmented by adding a microcomputer to record tank gunnery performance measures. Eighteen TC-gunner pairs were drawn from two armor units at Fort Knox and tested on 27 gunnery engagements using the TGMTS. For each TC-gunnery pair, engagement time and accuracy measures were recorded. These gunner performance measures were evaluated as a function of several variables including range to target and crew experience. Informal observations of equipment reliability and ease of use of TGMTS were also obtained.

Findings:

The research suggests that TC-gunner performance can be accurately and reliably measured using the computer-augmented TGMTS. The TC-gunner pairs tested on the TGMTS performed much as they might be expected to perform on the M60A3 tank. More experienced gunners had higher hit probabilities and faster engagement times than their less experienced counterparts. Hit probability also decreased in the expected direction as range-to-target increased. The TC-gunner pairs being tested had little difficulty using the TGMTS device, but the researchers found that setting up and aligning the TGMTS requires a moderate amount of technical expertise.

Utilization of Findings:

For evaluating gunnery performance when the firing tank is stationary the computer-augmented TGMTS has several characteristics that make it an excellent device. The computer-augmented TGMTS may be used for measuring gunnery performance in a number of different applications. Among the applications for which this device might be used are personnel assignment, diagnostic testing, evaluation of gunnery training programs and as a substitute for dry-fire or live-fire.

USING THE TANK GUNNERY AND MISSILE TRACKING SYSTEM (TGMTS)
FOR MEASURING TANK GUNNERY PERFORMANCE

CONTENTS

	Page
INTRODUCTION	1
Performance Measurement in the Army	1
The Tank Gunnery and Missile Tracking System	2
Previous Research	3
TGMTS as a Performance Measurement Device	4
Present Research	4
METHOD	4
Subjects	4
Equipment and Materials	4
Procedure	9
Analyses	11
RESULTS	11
Biographical Data	11
Mean Engagement Times and Hit Performance	12
Effects of Target Range and Task Replication on Performance	13
Effects of Previous Armor Experience on Performance	14
Use of Tank Sights and Gunnery Performance	14
Aiding Gunner Target Acquisition	16
Soldier Participant Comments	16
Reliability of Performance Measurement	16
Equipment Reliability Considerations	17
Film Quality	17
TGMTS Ease of Use Observations	17
DISCUSSION	18
Usefulness of Computer-Augmented TGMTS	18
Pros and Cons of Using TGMTS for Performance Measurement	19
Possible Applications for TGMTS in Performance Measurement	20
Concluding Remarks	21
REFERENCES	23
APPENDIX A. MICROCOMPUTER AND ASSOCIATED HARDWARE	A-1
B. COMPUTER-BASED BIOGRAPHICAL QUESTIONNAIRE	B-1
C. INSTRUCTIONS TO TGMTS OPERATORS AND SUBJECTS	C-1

Page

LIST OF TABLES

Table 1. Crew testing schedule 10

2. Primary performance measures 11

3. Means and standard deviations for biographical questionnaire items 12

4. Mean engagement items and proportion of target hits 13

5. ANOVA table for least-squares analysis 14

6. Correlations between biographical data and performance measures 15

7. Number of occasions in which each tank sight was used for firing the engagement 15

8. Correlations between performance measures and use of the unity window and multiple sights 16

LIST OF FIGURES

Figure 1. M60A3 turret trainer, TGMTS LOS projectors and computer hardware 6

2. TGMTS projection console unit, projector, and screen 7

3. TGMTS remote control unit 8

A1. Circuit diagram of data collection equipment A-2

USING THE TANK GUNNERY AND MISSILE TRACKING SYSTEM (TGMTS) FOR MEASURING TANK GUNNERY PERFORMANCE

INTRODUCTION

Performance Measurement in the Army

The Army continually monitors its own performance to ensure that it maintains readiness and retains a well-trained fighting force. From the time an individual joins the Army until his/her completion of service, the Army measures his/her skills and knowledges. Before entering the service, the soldier must take the Armed Services Vocational and Aptitude Battery (ASVAB). Performance on this battery may determine whether or not the soldier qualifies for a particular Military Occupational Specialty (MOS). Next, the soldier receives training in his/her MOS through institutional training programs. End-of-block or end-of-course tests are used to measure skill acquisition during this training. After graduation the soldier is assigned to a unit where he/she is tested at least once annually through Skill Qualification Tests (SQTs). SQTs are given to encourage soldiers to maintain the skills that are essential to performing their jobs. In some MOS's, additional demonstrations of skills are required, such as the annual gunnery qualification that armor crewmen must undergo. In order to pass, armor crewmen are required to score above a minimal level on the dozen or so tank gunnery engagements comprising Tank Gunnery Table VIII. Table VIII includes day and night main gun and machinegun engagements against stationary and moving targets. Informal performance assessment may also be conducted for diagnosis of performance deficiencies in determining who needs additional training.

Because the Army uses performance assessment in so many ways, the development of reliable performance measures is essential. To be useful, performance assessment measures must have high reliability and validity. A highly reliable measure is one that produces consistent scores for the same persons from one measurement occasion to the next. Measures with high validity are accurate in the sense that they measure the skills they purport to measure. Validity is typically evaluated by comparing performance as determined by the assessment technique with an independent measure of the skill. Ideally performance assessment measures should be inexpensive and easy to administer as well as possess high reliability and validity.

In practice few performance measures have high reliability and validity and are inexpensive and easy to administer as well. Present techniques for measuring Armor performance are either expensive and difficult to administer (e.g., Table VIII gunnery qualification) or else sacrifice hands-on skill measurement for more efficient and cheaper paper-and-pencil measures (e.g., SQTs). Despite the high cost and resource-intensive nature of Table VIII, its validity has been challenged (Blackburn, 1983; Wheaton, Fingerman, & Boycan, 1978). The reliability of Table VIII has also been questioned. Eaton and Whalen (1980) have shown that methods typically used in scoring live fire exercises such as Table VIII may be unreliable. Table VIII reliability may be low because only a few engagements of each type are included. In general longer tests (i.e., tests with more items) are more reliable (Gulliksen, 1950).

Questions have also been raised regarding the validity of SQTs. In some cases the optional hands-on portion of the SQT is not administered because of the demands placed on the units' time and resources, and Eaton, Johnson, & Black (1980) cite evidence that indicates that paper-and-pencil tests are poor predictors of gunnery performance. Thus an SQT for gunnery that relies entirely on paper-and-pencil measures is not likely to accurately assess gunnery skills. The Army clearly needs to consider alternatives to its current methods of performance assessment.

The Army has acquired a variety of simulators for providing realistic training while reducing training costs. Among these are simulators for training tank gunnery (e.g., MK60, U-COFT, TGMTS). Because these simulators have been developed for training soldiers, they are often referred to as training devices. But each of these devices have some built-in performance measurement capabilities. Although these capabilities were included to facilitate training by providing feedback about performance to the soldier or instructor, these same capabilities may be utilized in performance assessment applications. If need be, a training device can be modified or augmented to provide additional performance assessment capabilities.

The Tank Gunnery and Missile Tracking System

One device that has potential in assessing gunnery performance is the Tank Gunnery and Missile Tracking System (TGMTS). TGMTS is a tank-appended simulation device that simulates engagements in which a stationary tank fires at stationary and moving targets. The TGMTS uses a rear-projected movie that depicts armor targets moving across realistic terrain. Targets are engaged by following normal tank gunnery procedures. As armor crewmen track targets through their sights, infrared line-of-sight projectors mounted on the tank turret and optical devices on the projector console track the line-of-sight aiming point. When the main gun is fired, the TGMTS fires an eye-safe laser that simulates the flight and strike of the round on the screen. A red laser dot indicates the point that the round impacts the target scene. Adding to the realism is a loud boom emanating from a loudspeaker each time that the gun is fired. Some versions of the TGMTS include an optional laser range simulator for use with the Laser Rangefinder found on modern US tanks. Smoke or fog can be simulated through the use of an optional shutter mechanism that covers each tank sight with selected filters. Another option available with the TGMTS is an Engagement Time Recorder that records time required for soldiers to complete engagements and provides a hard copy of the same.

Since its introduction in the late 1970's, the TGMTS has undergone several modifications designed to increase its fidelity as a gunnery trainer and to improve its reliability of operation. The most recent version, the MK.4 is reportedly more accurate and reliable than previous models. The MK.4 also has capabilities not available with earlier models (DETRAS, 1982). Enhancements to the MK.4 TGMTS include the Multiple Burst Control Console (MBCC) for simulating machinegun engagements. Other reported improvements include increased device accuracy (to within 0.5 mil of the aim point) and sharper images in the filmed battlefield scenes. The developer of TGMTS has proposed a Thermal Image Simulator for the MK.4 that permits the gunner to use his thermal sight along with his normal sight reticle. The thermal image is

produced by utilizing a video camera mounted on the tank adjacent to the thermal sight. The electrical output of the video camera is processed and drives a thermal display. The thermal display is mounted directly in the line of sight of the thermal sight, which views the thermal display through a focus-correcting infrared lens.

Previous Research

Initial favorable reactions to the TGMTS have led to their widespread use in Armor training. TGMTS are presently being used in the US and Europe. Additional units are being purchased for use in Korea. The US Army Armor Engineer Board (Sigtenhorst and Johnson, 1982) assessed training effectiveness by comparing the performance on a modified Table VI of TGMTS-trained students with that of students trained using selected subcaliber devices (M55 laser and .22 caliber). Performance measures collected were gunner's lay accuracy and engagement times. The TGMTS was supplemented with video and event recording equipment for obtaining reliable performance measures. Records of TGMTS malfunctions during testing provided estimates of equipment reliability, and information of ease of use came from instructor and student comments and from observation by test administrators.

Sigtenhorst and Johnson found the TGMTS training effectiveness was about equal to that of the subcaliber devices. With regard to equipment reliability, the TGMTS developed 13 malfunctions over the 60 hours of testing. Most of these were alignment problems produced by overheating of the TGMTS. Instructors experienced no problems in installing and operating the device other than some difficulty in performing alignment procedures. Students liked training with the device, and felt that the performance scoring and feedback features greatly aided them in correcting gunner mistakes. Instructors generally praised the TGMTS, especially the realism of the device and its scoring and feedback features.

Ogle (1983) reported data o the validity of the TGMTS gathered during a Weapons Crew Training Test. Although the test was not structured to evaluate the TGMTS, some interesting results were obtained. Twelve tank crews received training on the TGMTS and were then tested on a modified Table VIII. The proportion of target hits achieved during TGMTS training was recorded and compared with performance on the Table VIII. A significant positive correlation between the number of main gun engagements qualified on Table VIII and the proportion of hits on the TGMTS was found. These results suggest that performance on the TGMTS may predict performance during live fire exercises. However the results were based on a small number of cases, and any conclusions drawn regarding the validity of the TGMTS are tentative and must await further research.

TGMTS as a Performance Measurement Device

From the foregoing discussion there is much to recommend TGMTS in performance assessment. The newer versions of the TGMTS are high fidelity devices that allow armor crewmen to utilize nearly all of the weapon system

capabilities of modern US tanks, including the laser rangefinder, machineguns, and all controls and daylight sights. With the proposed modifications, use of the gunner's thermal sight will be included as well. Based on its high fidelity one might expect the TGMTS to be a good device for assessing soldier performance. Factors other than fidelity such as reliability of measurement and validity will ultimately determine the usefulness of TGMTS for performance assessment. Reliability depends on the capability of a device to consistently measure skills and knowledges. Consistency from one measurement occasion to the next requires that an adequate sample of the skills in question be obtained, testing conditions remain constant, and error in measuring the skills be minimized.

Because TGMTS was designed as a training device, it lacks certain features that are needed for reliable performance assessment. While the TGMTS is designed to present tank gunnery engagements in a consistent manner under controlled conditions, it lacks an integrated method of recording and storing crew performance data. An optional time recorder is available for making permanent records of total engagement times, but no other data are recorded. Missing are features for easily scoring and recording firing accuracy and methods for measuring and recording the gunnery activities affecting engagement speed (e.g., target acquisition and identification times).

Present Research

This report describes how interfacing the TGMTS with a microcomputer can enhance its performance measurement capabilities. To illustrate the usefulness of the approach, the performance of 18 TC-gunner pairs was assessed using the TGMTS-microcomputer combination. The present research investigates the potential of the microcomputer-aided TGMTS for measuring gunnery performance. Advantages and disadvantages of the TGMTS-based performance measurement system are discussed.

METHOD

Subjects

Eighteen tank commander-gunner pairs each were drawn from two Armor units at Fort Knox. Half of the pairs were drawn from the primary support unit for the post, and the remaining pairs came from an operational Armor unit. All subjects, regardless of unit, were qualified tank commanders (TCs) or gunners on M60A3 tanks.

Equipment and Materials

The primary equipment used in this research included: (1) an M60A3 turret trainer, (2) a prototype of the Tank Gunnery and Missile Tracking System

(TGMTS), (3) three target engagement films and one practice film, (4) two Apple II microcomputers, and one reel-to-reel dual track tape recorder. The materials utilized in this effort were a biographical questionnaire for TCs and gunners, and the software for scoring and recording performance.

The M60A3 turret trainer consists of an actual M60A3 tank turret mounted on a turret stand. Except for its inability to move and fire live rounds, the M60A3 turret trainer is functionally identical to an M60A3 tank. Fitted with the TGMTS equipment, the trainer allowed full use of all switches, controls, and sights with the exception of the thermal sight and gunner's unity window. The 1x power unity window was partially blocked by one of the TGMTS Line-of-Sight (LOS) projectors, and the prototype TGMTS used did not have thermal capability. A relay and two switches were placed inside the turret for recording palm switch release, lase, and fire times. All times were measured from the moment that an engagement was first presented. By releasing the power control handle the TC hands off the target to the gunner. Lase time refers to time that the gunner fires a laser to obtain the target range. Microphones for recording TC-gunner interactions were placed in the crew compartments.

The TGMTS used in this research was a prototype of the device. It included an LOS projector for each of the three M60A3 sights. A laser range simulator was attached to the turret's Laser Rangefinder. All operations of the TGMTS were controlled from the remote control unit. The projection console unit required an external fan for cooling. The prototype TGMTS simulated main gun firing; the optional machinegun simulator and Engagement Time Recorder were not available.

Four films supplied with the TGMTS provided all target engagements used in the study. One film, used for practice, included 18 engagements in which stationary and moving targets were surrounded by terrain features like those that might be seen in the eastern United States. The other films had nine engagements each. They were filmed in a desert-like environment such as may be found in the western or southwestern U.S. The range at which the targets appeared on the screen varied from one engagement to the next as did the time that targets were presented.

To facilitate the collection of performance data an Apple microcomputer was interfaced with the TGMTS and M60A3 trainer. The microcomputer recorded the time of occurrence of key events during simulated target engagements. Among the events recorded were engagement start time, fire command time, palm switch release time, lase time and fire time. A complete list of microcomputer components and associated hardware is found in Appendix A.

Figures 1 and 2 show the arrangement of the computer-augmented TGMTS components. Figure 1 shows the location of the LOS projectors and computer hardware. Not shown in the figure is the laser range simulator located behind the TC's LOS projector and the tape recorder just to the rear of the loader's hatch. Figure 2 shows the film projector, projection console unit, and the rear-projected screen. The screen was placed midway between the turret trainer and the film projector 5.6 meters from each. The TGMTS remote control unit is shown in Figure 3. A circuit diagram showing equipment interconnections is included as Figure A-1 in Appendix A.

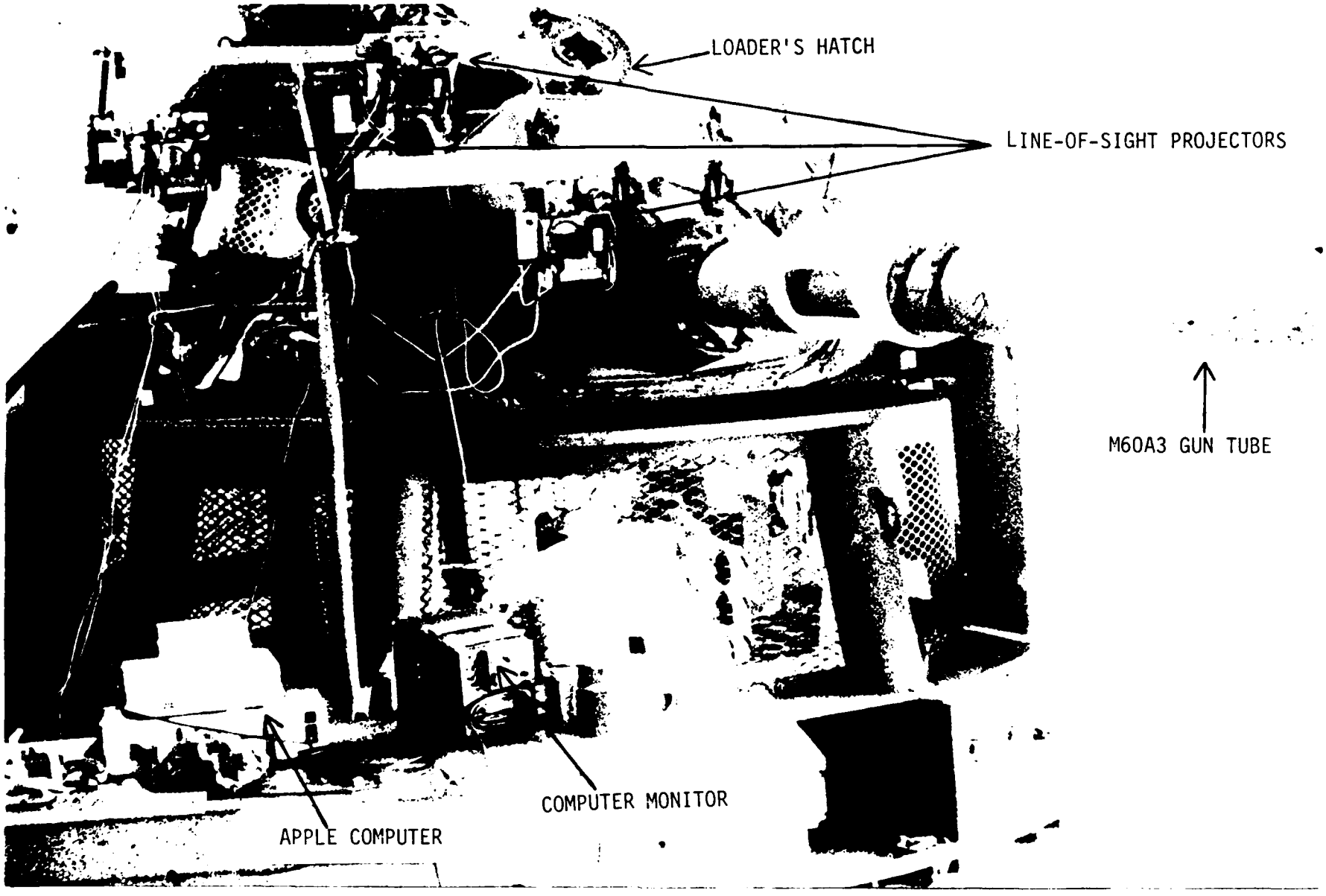

Figure 1. M60A3 turret trainer, TGMTS LOS projectors and computer hardware

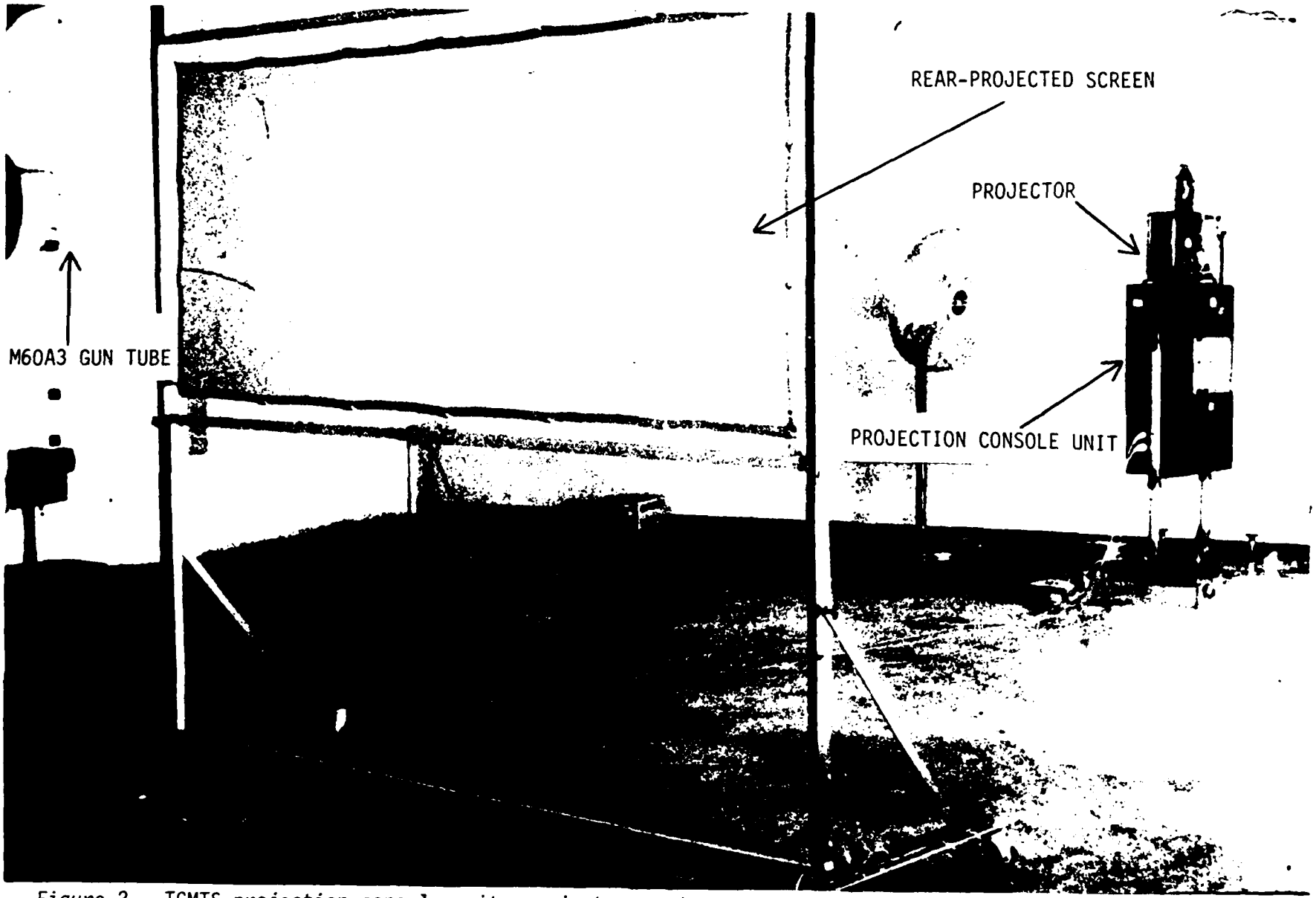

Figure 2. TGMTS projection console unit, projector, and screen.

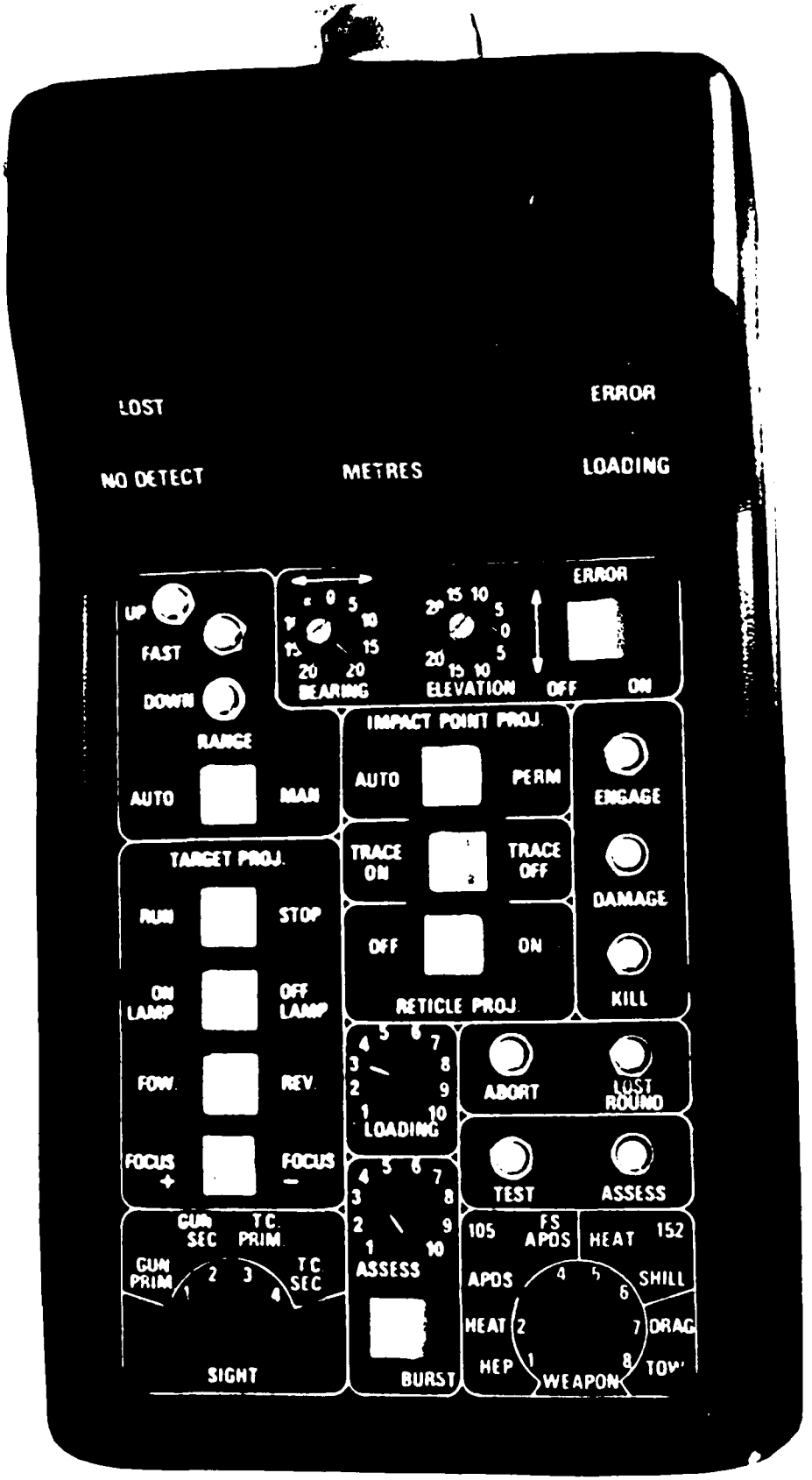

Figure 3. TGMTS remote control unit.

The biographical questionnaire was designed to obtain information about the training and experience of the TCs and gunners. A copy of the questionnaire is included in Appendix B. The questionnaire was computer administered and responses were stored by subject in a biographical data file.

Custom software was developed for presenting trial conditions and recording performance data. The software presented the conditions associated with each trial (i.e., film, engagement number, range) to the computer operator and recorded specified performance measures.

Procedure

The same target scenes from the practice and test films were presented to all TC-gunner pairs. Subjects differed from one another only in the order that the films were shown. The presentation order of test films was counterbalanced so that each film was shown first, second, and third on an equal number of occasions. Subjects were assigned randomly to one of the three film presentation orders. Target engagements within films were always presented in the same order because of limitations inherent in film media presentation techniques.

TC-gunner pairs were tested in either a morning or afternoon session. Two TC-gunner pairs were tested during each session. The sequence of testing is shown in Table 1. Each TC-gunner pair first completed the biographical questionnaire (see Appendix B) and then received instructions explaining operation of the TGMTS and test procedures (See Appendix C for instructions to subjects). Eighteen practice engagements were presented to allow the crewmen to practice their target engagement techniques on the TGMTS. Following practice, the crewmen engaged targets from the first test film. Only one simulated round was allocated per target scene. After completing the first test film, crewmen were given a break (20-40 minutes) before engaging targets on the remaining two films.

Prior to each testing session the TGMTS LOS projectors were aligned and the A3 trainer was boresighted with the TGMTS. All A3 trainer switches and controls were returned to their original positions, and the microcomputer was prepared for data collection. The tape recorder was switched on and set for recording.

Three test administrators needed to be present at all times. One administrator was responsible for all operations involving the Apple II microcomputer. Another was responsible for operating and maintaining the TGMTS equipment and a third administrator was located inside the turret with the crew to instruct the crew and record the occurrence of specific behavioral events. See Appendix C for instructions to test administrators.

All TC-gunner pairs received 27 test engagements, nine per film. A typical test trial occurred in the following manner. The TC was instructed to align the main gun with the left-hand side of the movie screen. The microcomputer operator called out the target range for the upcoming engagement to the TGMTS controller, who entered the range in the TGMTS from the

remote control unit. The TGMTS controller started the film and the microcomputer operator marked the engagement onset by hitting an event key. The TC acquired the target and gave a fire command. The microcomputer operator marked the fire command time by hitting an event key. The TC then laid the gun in the target areas and waited for the gunner to say "IDENTIFIED." When the TC heard "IDENTIFIED," he released the palm switch on his override control. This event was automatically recorded by the microcomputer. The gunner then attempted to track the target. When the gunner announced "LASING," the test administrator inside the turret prepared to mark the lasing event by pressing a switch linked to the microcomputer. When the gunner pressed the lase button, the test administrator pressed the switch. The gunner continued to track. When he fired, the trigger squeeze was automatically recorded by the microcomputer, the TGMTS film froze and the computer operator scored the engagement. Engagements were scored as hit, miss, or near miss (i.e., the round landed within two target forms of the vehicle). No reengagements were allowed.

Table 1

Crew Testing Schedule

Time	Events for Crew 1	Events for Crew 2
0800/1300	Biographical questionnaire Test instructions Practice engagements First film	Biographical questionnaire (Break)
0900/1400	(Break)	Test instructions Practice engagements First Film
1000/1500	Second film Third film	(Break)
1100/1600	(Dismissed)	Second film Third film (Dismissed)

The primary performance measures obtained during the test trials are shown in Table 2. In addition to these measures, the observer recorded which sights were used by the TC and gunner to acquire and engage targets. Use of more than one sight (i.e., multiple sights) during an engagement was recorded by crew for each target engagement. All communications between the TC and gunner (e.g., fire commands, target sensings) were recorded on audio tape.

Table 2

Primary Performance Measures

Event	Measure
Fire Command	Time
Palm switch release	Time
Lase	Time
Fire	Time and accuracy
Acquiring and tracking target	Sight used
Firing at target	Sight used

In addition to the crew performance measures, informal observations of the equipment reliability and ease of use of the TGMTS were obtained. No formal RAM assessments were made. Because the TGMTS evaluated was a prototype version of the device, some observations may not apply to more recent versions of the TGMTS, such as the MK.4.

Analyses

The primary dependent measures examined in this research were hit assessment and engagement time. The relationships between these measures and other variables of interest (e.g., target range, gunner experience, replication) were evaluated using correlation and contingency analysis. The effects of replication and range on engagement time were assessed using a least squares analysis (Kirk, 1968). Replication refers to repetition of the basic experimental design for each film. While all subjects were tested on each of three films, all subjects did not see the films in the same order. The first film presented to a subject constituted the first replication for that subject, while the second and third films presented constituted the second and third replications, respectively. A significant replication effect would indicate that the subject's performance improves from one film to the next.

RESULTS

Biographical Data

The biographical data (see Table 3) show that the gunners and TCs tested had nearly 8 1/2 years of armor experience on the average. Their time as M60A3 crewmen was also relatively high, averaging about 2 1/2 years. Specific experience as an M60A3 gunner or TC though was limited, averaging from 6 to 8 months. Most of the TC-gunner pairs tested had not previously trained together. One third of the TC-gunner pairs had previous experience with the TGMTS; career number of TGMTS sessions averages about six sessions per crew. In summary, biographical data show that the average TC-gunner pair had substantial armor and M60A3 experience, but time in position (i.e., gunner or TC) was limited as was time trained together as a crew. The majority of TC-gunner pairs had not previously used the TGMTS.

Mean Engagement Times and Hit Performance

Table 4 presents mean engagement times and proportion of targets hit. The engagement component times listed in the table represent specific activities undertaken by the TC or gunner or both. The first component represents the time from the start of the engagement when the target scene begins to the TC's initiation of the fire command. The next component starts when the fire command is issued and ends when the TC releases his palm switch (PS). The third component time begins when the PS is released and ends when the gunner or TC activates the laser rangefinder (LRF). The last component time starts with the lase and ends when the gunner or TC fires the simulated round. These component engagement times provide information about the time required to perform each of the primary activities from the presentation of a target until the firing of the first round.

Table 3

Means and Standard Deviations for Biographical Questionnaire Items

Item	Mean	S.D.
Time in armor (years)	8.42	4.09
Time as M60A3 crewmen (mos.)	31	17.85
Time as M60A3 TC (mos.)	7.5	6.16
Time as M60A3 gunner (mos.)	5.72	5.27
Time assigned together as TC and gunner (mos.)	0.72	1.56
Time trained together as TC and gunner (mos.)	0.61	1.54
Ever trained together?	4 of 18 crews	
Ever used TGMTS?	6 of 18 crews	
Career number of TGMTS sessions	6.39	21.04
Length of time since last TGMTS sessions (MOS)	10.57	4.69
Wear glasses?	6 of 36 crewmen	
Use glasses when firing	2 of 6 crewmen	

Inspection of the engagement component times in Table 4 shows precisely how long each part of the engagement sequence required. For example, the TCs required almost 7 seconds on the average to locate target and initiate their fire commands. TC-gunner pairs used an additional 6 seconds for the TC to lay the gun in the vicinity of the target and the gunner to detect the target. The gunners required an average of 5 1/2 seconds to lay on the target and lase to it following detection. Finally 5 seconds was required for the TC to evaluate the range returned by the Laser Rangefinder, issue the order to fire, and the gunner to fire the round.

The total engagement time for the TC-gunner pairs as a group averages about 23 seconds. These times are slow compared to current gunnery standards for similar engagements. The engagement component times may be used to determine where valuable time is being lost. For example, data in Table 4 suggest that TCs are taking too much time to locate the target and lay the gun for direction. Similarly the data indicate that gunners are unnecessarily slow in laying the gun on the target and lasing to it.

Table 4

Mean Engagement Times and Proportion of Target Hits

Performance Measure	Mean	S.D.	N
Engagement Component Times (secs)			
Start to Fire Command	6.71	5.91	477
Fire Command to PS Release	6.32	8.93	475
PS Release to Lase	5.53	10.75	447
Lase to Fire	5.00	11.37	445
Total Engagement Time (secs)	23.44	12.13	486
Proportion of Hits	0.46*		486

*Note. The proportion of hits was determined by dividing the total number of targets presented by the number of target hits.

Effects of Target Range and Task Replication on Performance

Firing accuracy and time-to-engage were evaluated as a function of target range and task replication. As range to target increased, the number of target hits decreased. The proportion of hits at ranges less than 1000 meters, between 1000 and 1500 meters, and greater than 1500 meters was 0.69, 0.33, and 0.31, respectively. The correlation between number of target hits and range to target was significant ($r = -.58$, $p < .01$). In contrast no

relationship between firing accuracy and replication was obtained (X^2 = 4.84, df = 4, N.S.), indicating that firing accuracy did not improve from one film to the next.

The effects of range and replication on time-to-engage targets were examined by transforming engagement times using a logarithmic transformation and performing a least-squares analysis (Kirk, 1968) on the transformed times. The logarithmic transformation was required because of heterogeneity of variance existing across replications. The results of the least-squares analysis are shown in Table 5. A significant effect was obtained for replication but not for range. The significant effect was due largely to faster engagement times on the third replication. Untransformed means of engagement times for replications 1, 2, and 3 were 23.02 seconds, 22.72 seconds, and 19.38 seconds, respectively.

Table 5

ANOVA Table for Least-Square Analysis

Source	SS	df	MS	F
Rep (adj)	0.993	2	0.4965	5.07*
Range (adj)	0.493	2	0.2465	2.52
Rep x Range (adj)	0.207	4	.0518	0.53
W. cell	20.96	214	.0979	

* $p < .01$

Effects of Previous Armor Experience on Performance

To determine the relationship between previous training and experience and gunnery performance on the TGMTS, correlations between the biographical measures and performance measures were computed. The results are shown in Table 6.

Of the biographical measures tested, only the amount of time as an M60A3 gunner was significantly correlated with the performance measures. The results suggest that gunners with more M60A3 gunnery experience engage targets faster (i.e., shorter engagement times) and achieve more target hits than less experienced gunners. Somewhat surprising was the nonsignificant positive correlation between time as an A3 TC and engagement time. In fact TC experience did not significantly correlate with either performance measure.

Use of Tank Sights and Gunnery Performance

Table 7 shows the number of times each sight was used for firing engagements by the subjects. Also shown are the number of engagements in which the crews failed to fire. The most striking results shown in the table is the gunners' consistent use of the gunner's primary sight. Better than 93% of

the engagements completed were fired from the gunner's primary sight. Tank commanders rarely fired from their sights, although this option was open to them. The hit percentage for engagements on which a round was fired was about 50% regardless of the sight used for firing or whether the gunner or TC fired.

Table 6

Correlations Between Biographical Data and Performance Measures

	Time in Armor	Time on M60A3	Time as A3 Gunner	Time as A3 TC	Time trained together	No. of TGMTS sessions
Number of Hits	0.23	0.19	0.65**	-0.29	-0.27	0.17
Average Time-to-Engage	0.07	0.11	-0.49*	0.32	0.07	0.24

* $p < .05$
** $p < .01$

Table 7

Number of Occasions in which Each Tank Sight Was Used for Firing the Engagement

Sight Used				
Gunner's Primary Sight	Gunner's Secondary Sight	TC's Sight	No Fire	Total
414	23	6	43	486

While the gunner's primary sight was most often used for firing, other sights also figured into the total engagement equation. The use of more than one sight during an engagement (i.e., multiple sights) was employed in approximately 12% of the engagements presented. The gunner's unity window was used in acquiring targets in about 8% of the engagements, but was not used in firing. Correlations between the use of the unity window or multiple sights and gunnery performance measures are shown in Table 8. The table shows that the number of times that a crew used the unity window was significantly correlated with target hits, but not with engagement time. Use of multiple sights was not significantly correlated with either target hits or engagement time.

Aiding Gunner Target Acquisition

In monitoring crew activities, the observer noted that TCs sometimes talked their gunners onto the target when gunners experienced difficulty acquiring targets. TCs pointed out terrain features in the vicinity of the target and gave their gunners feedback on their aim. TCs talked their gunners onto the target in 38 of 486 engagements or 8% of the engagements presented. Of these 38 engagements hits were achieved on 23, or 61%. This hit percentage is about 10 points higher than the average overall hit rate of 50%. A statistical test of the relationship between talking the gunner onto the target and number of hits, however, indicated that the relationship was not significant ($X^2 = 3.07$, N.S.). That is, no relation between talking the gunner onto the target and hit probability was obtained.

Table 8

Correlations Between Performance Measures and Use of the Unity Window and Multiple Sights

	Performance measure	
Sights used	Number of target hits	Engagement time
Unity window	0.53*	-0.27
Multiple sights	0.10	-0.11

* $p < .05$

Soldier Participant Comments

Immediately following their participation in the test, soldiers were asked for their comments. Of the 36 comments received 20 were positive and 16 were negative. Positive comments indicated that the training provided by the TGMTS was challenging, fun and interesting. Some soldiers said that they would like to get additional training on the TGMTS. Training with the TGMTS was said to be realistic and to provide good practice for target acquisition and engaging moving targets. Negative comments were primarily directed at the film quality and the accuracy of the strike of the simulated round. The soldiers commented that the film was sometimes blurry and indicated that the laser dot did not always strike where they had aimed.

Reliability of Performance Measurement

The reliability of measuring performance with the TGMTS was estimated by calculating the split-half reliability for firing accuracy. The split half reliability was calculated by obtaining the number of target hits for the first twelve engagements and correlating these with the number of hits

obtained for the last twelve engagements using the Spearman-Brown formula. Engagements included in the two halves were of comparable difficulty. Data from the first engagement in each of the three films was not used in the calculation so that the calculation was based on an even number (24) rather than an odd number (27) of engagements. Using this method, the estimated reliability of firing accuracy as measured by the prototype TGMTS was $r_{11} = 0.47$ ($p < .05$). The reliability of engagement speed could not be estimated because of insufficient data.

Equipment Reliability Considerations

The data reported here were gathered as part of a larger study in which the TGMTS was used for slightly more than 100 hours. During this time the following problems were encountered:

- Two modules on the projector control console failed and were replaced.
- The target projector lamp failed and was replaced.
- The amplifier controlling the sound of the simulated round failed and was repaired.
- The sensitivity of the detector that affects how well the laser tracks the infrared beam decreased and had to be adjusted on several occasions. Precise adjustment of detector sensitivity was critical for the proper operation of the TGMTS.
- The accuracy of the strike of the simulated round as the aim point moved from the center of the screen to the far left or right edges decreased significantly. Errors as much as 2 1/2 to 3 1/2 mils were recorded when the aim point was near the edges of the target scene.
- To prevent overheating of the projector control console electronics, the cover of the console had to be removed and a large fan directed toward the console.

Several of these problems required technical support from DETRAS, the developer and manufacturer of the TGMTS.

Film Quality

The quality of the films provided with the TGMTS prototype was marginal. The targets were not clearly depicted against the background scenery and were more difficult to detect than they would have been in an actual daylight scene. Furthermore the quality of the filmed scenes relative to that of actual daylight scenes appeared to decrease as target range increased.

TGMTS Ease of Use Observations

For the most part TC-gunner pairs had no trouble using the TGMTS to engage targets. Two notable exceptions, however, are worth mentioning. The

manner in which the LOS projector for the gunner's primary sight mounts to the M60A3 turret partially blocks the gunner's view from his unity window, making target acquisition more difficult. Some gunners were further hampered in target acquisition because of the way that the TC must lay the main gun in order for the target to appear in the gunner's sight picture. With the TGMTS, the TC in laying the gun for direction, must point the gun tube low and to the left if the gunner is to easily acquire the target. Some TCs had difficulty adjusting to the requirement and continued to point the gun tube directly at the target.

For personnel conducting training and evaluating performance, use of the TGMTS was relatively easy once the tedious task of setting up and boresighting the TGMTS had been completed. The most difficult part of setting up the TGMTS was mounting each of three LOS projectors on the tank turret. Mounting the projectors was difficult because of the weight and bulkiness of the equipment, and the requirement to position it correctly and attach it securely to the tank. To mount the gunner's primary sight projector to the turret, it was necessary to drill an extra hole in the mounting hardware in order to align the projector with the primary sight. Boresighting requires that each sight be aligned with the center of the screen and that the gimble knobs on the corresponding LOS projectors be adjusted to cause the laser dot to coincide with the sight alignment. Boresighting the TGMTS requires close coordination between a person in the tank who aligns the sights and monitors the relationship between where the sight is aiming and the red laser dot and the person adjusting the gimble knobs on the LOS projector. The gimble knobs must be set very precisely to boresight the device properly. The gimble knobs on the prototype TGMTS in some cases were hard to reach and turn, increasing the difficulty of boresighting the system.

DISCUSSION

Usefulness of Computer-Augmented TGMTS

Use of the computer-augmented TGMTS allowed us to examine gunnery performance very closely. The microcomputer recorded interresponse times and total engagement times both accurately and efficiently. It also provided a simple means of recording hit assessments. Experimental conditions for each trial, such as target range, film identifier, and engagement number were easily tracked by the computer. Although not utilized in collecting the data for this report, the TGMTS shutter mechanisms could also be controlled by the microcomputer.

The data obtained in this research supports the contention that the TGMTS accurately measures gunnery skills of TC-gunner pairs. For example, more experienced gunners hit more targets and engaged these targets faster than less experienced gunners during the test. If TGMTS accurately measures gunnery skills, one would expect more experienced gunners to exhibit superior performance on the device. Hit percentages using the TGMTS varied with range in a predictable manner. The hit percentage was relatively high at ranges less that 1000 meters, but the percentage dropped sharply at ranges exceeding 1000 meters up to about 1500 meters. At ranges greater than 1500 meters performance began leveling off, declining at a much slower rate. A similar relationship between hit percentage and range has been observed when actual

tanks fire live rounds (AMSAA, 1977; AMSAA, 1980). The gunnery performance of TC-gunner pairs improved with practice on the TGMTS; that is, crews engaged targets faster with the TGMTS after training with the device. This improvement in performance is what one might expect if the TGMTS reliably measures gunnery performance. Although transfer of this training to the actual equipment was not tested, it is likely that the practice effects would carry over to the M60A3 tank, based on the similarity of the A3 trainer to the tank and the realism of the target scenes presented.

While gunner experience seemed to affect tank gunnery performance as tested on the TGMTS, TC experience had no effect. Because the gunners did most of the firing, TC experience would not be expected to affect firing accuracy. However, experienced TCs might be expected to issue fire commands and lay the gun for direction faster than less experienced TCs, thereby decreasing engagement times. TC experience may not have affected engagement times due to the requirement for the TC to learn a new response (i.e., lay the gun tube low and to the left of the target). Alternately the experience level of the TCs may have been outweighed by the experience level of the gunners which with they were paired. For example eight of the ten experienced TCs were paired with inexperienced gunners and these pairs tended to have slow engagement times. Such TC-gunner pairings may have increased engagement times for experienced TCs, thus reducing the differences between crews with experienced TCs and those with inexperienced TCs.

Pros and Cons of Using TGMTS for Performance Measurement

This research suggests that gunnery skills of TC-gunner pairs can be precisely measured using a computer-augmented TGMTS. Accurate measurement of engagement component times permitted the examiner to identify specific TC and gunner performance deficiencies. While the accuracy of the strike of the simulated round was adequate for identifying performance deficiencies, the prototype TGMTS became less accurate as the target moved from the center of the screen. This measurement error reduced the reliability of measuring firing accuracy below what might have been obtained with the newer versions of the TGMTS, and probably contributed to the lower than expected split-half reliability obtained for the 18 TC-gunner pairs.

The type of gunner skills measured by the TGMTS is limited by the capabilities and features of the device. For example, the prototype TGMTS employed in this research could only be used to measure performance during daysight main gun engagements. With the MK.4 version of the TGMTS machinegun engagements may be added, and with the optional thermal image simulator, thermal engagements may be included. The TGMTS, however, cannot be used to measure the capability of TC-gunner pairs to fire on the move, nor can it simulate the drivers role in gunnery engagements since the firing tank does not move. The TGMTS also does not lend itself to engagements in which other friendly tanks are assisting in the engagement (e.g., the wingman concept).

Although the limitations of the TGMTS precludes its use in some situations, the TGMTS coupled with the microcomputer has numerous features that make it an excellent device for assessing gunnery performance. In fact, performance measurement with the computer-augmented TGMTS may be more efficient and realistic than measuring performance on the actual equipment.

Measuring gunnery performance with the TGMTS is more efficient than live fire measurement because the cost in resources is much less. Firing with the TGMTS requires no ammunition, no fuel, and fewer personnel than would live-fire exercises. At first glance, nothing short of actual combat is more realistic than live-fire exercises. However live-fire exercises such as Table VIII typically involve firing at pop-up targets or target silhouettes moving in predictable ways at predictable locations within the predefined boundaries of familiar terrain. In contrast, the location and movement of targets in the TGMTS film are not predictable, given several films that crews have not previously seen presented in a random order. Furthermore, the TGMTS films depict real targets (as opposed to mock-ups) moving across varied types of terrain.

The reliability of measuring performance with TGMTS would be expected to be higher than live-fire measurement based on the following considerations. With the computer-augmented TGMTS, precise performance measures can easily be obtained for a large number of different target scenarios. In general, including more target scenarios would increase the reliability of measuring gunnery performance. Because of the time and expense of firing live rounds, live-fire exercises such as Table VIII generally include only about a dozen or so engagements. Scoring engagements is typically more difficult and less precise during live-fire exercises than with the TGMTS. Live fire scoring could however be improved by automating the scoring procedure, so that scoring no longer depends on the judgements of observers. The precise scoring available with the computer-augmented TGMTS is primarily due to automation of scoring procedures. Previous reliability coefficients calculated for live fire exercises have varied, widely ranging from -0.21 (Powers, McCluskey, Haggard, Boycan, and Steinheiser, 1975) to 0.73 (Eaton, Bessemer, & Kristiansen, 1979). The reliability coefficient obtained for the prototype TGMTS used in this research was 0.47. Two factors might account for this lower-than-expected reliability. As previously discussed, the strike of the simulated round became less accurate as the targets moved from the center of the screen. Had the more accurate MK.4 version of the TGMTS been used a higher reliability might have been obtained. The reliability coefficient obtained might also have been artificially lowered by including only 24 engagements that failed to challenge the relatively homogeneous group of soldiers tested. Using a less homogeneous group of soldiers or increasing the number and range of engagement difficulty levels would tend to increase between subject variability, and probably improve the measurement reliability. Increasing the number of engagements included in the test would also provide a more stable measure of individual gunner proficiency, thereby increasing performance measurement reliability.

Possible Applications for TGMTS in Performance Measurement

The characteristics of the TGMTS make it a good performance measurement device for a number of applications. Among the applications for which TGMTS might be used are personnel assignment, diagnostic testing, evaluation of training programs and qualification. Each of these applications will be discussed briefly below.

In testing the 18 TC-gunner pairs, gunnery skill varied greatly, even among those with little or no previous M60A3 gunnery experience. Some

inexperienced gunners hit nearly twice as many targets as others. This suggests marked individual differences in basic gunnery abilities. It also suggests a possible application for the computer-augmented TGMTS. The TGMTS might be useful in assessing basic gunnery ability of several would-be gunners in order to assign the most qualified soldiers to the gunner's position. The candidates with a relatively high percentage of targets hits and who show some improvement in accuracy or engagement speed over trials would be selected.

Once or twice a year armor units undergo a gunnery training phase in which most of their resources and energies are directed toward raising the gunnery proficiency of unit personnel. The training during this phase can include dry-fire exercises, use of training devices and live-fire exercises. Doctrine, however, dictates that the training meet certain requirements as specified in gunnery tables. During much of the gunnery training, performance measurement is the exception rather than the rule, and when performance is measured it is often not measured well. Often neither the individual crews nor the unit knows their level of gunnery proficiency.

The computer-augmented TGMTS can be used to diagnose performance deficiencies during the gunnery training cycles. The precision with which performance can be measured by the TGMTS will allow the unit to determine which TC-gunner pairs are having problems and what those problems are. Crewmen who require additional training can be identified early in the gunnery training cycle and remedial training can be administered prior to qualification runs or unit exercises. When the engagements specified in the tank tables are trainable with the TGMTS (e.g., as in tank Tables I and II), the TGMTS can be used for conducting the tables and performance evaluated in conjunction with the required training.

During armor basic training, at least one section of the course is devoted to gunnery. Determining progress during this training and to evaluating gunnery proficiency at the end of the course may be accomplished with the TGMTS. By using the TGMTS, the instructor can determine exactly how proficient each soldier is at specific gunnery tasks at any point in time. Tasks or soldiers exhibiting deficiencies can then be selected for intensive training.

Another possible application for using the TGMTS in performance measurement is in determining gunnery proficiency for crew qualification purposes. TGMTS engagements might be substituted for Table VIII main gun and machinegun engagements in which the firing tank is stationary. The advantages of the TGMTS over Table VIII live fire for performance assessment have been enumerated previously. If live-fire of Table VIII is considered a necessity, then 20 to 30 main gun and 10 to 15 machinegun engagements on the TGMTS might be used as additional qualification trails, thereby increasing the overall reliability of performance measurement for determining tank crew qualification.

Concluding Remarks

A modification to the TGMTS that allows automated measurement of gunnery performance has been described. The usefulness of this augmented TGMTS in measuring performance of 18 TC-gunner pairs was demonstrated. Gunnery

performance of the TC-gunner pairs as measured by the augmented TGMTS was similar to what might be expected if the actual equipment were used. Within the limits of the capabilities of the device as described in this report, the computer-augmented TGMTS has the potential to measure the tank gunnery performance of TC-gunner pairs efficiently and reliably.

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APPENDIX A
MICROCOMPUTER AND ASSOCIATED HARDWARE

Equipment	Qty
Apple II Plus Computer	1
Disk Drives	2
Mountain Computer Apple Clock	1
Monitor	1
Input-Output Module Board	1
12 Volt Relay	1
24 Volt Relay	2
Pushbutton Trigger Switch	2
Cables	2

The input/output module along with relays, trigger switches and cables provided the interface between the Apple computer and the A3 trainer - TGMTS gunnery simulator. This int -face allowed the computer to record TC gunner responses during an engagement. A schematic of the interface is shown in Figure A-1.

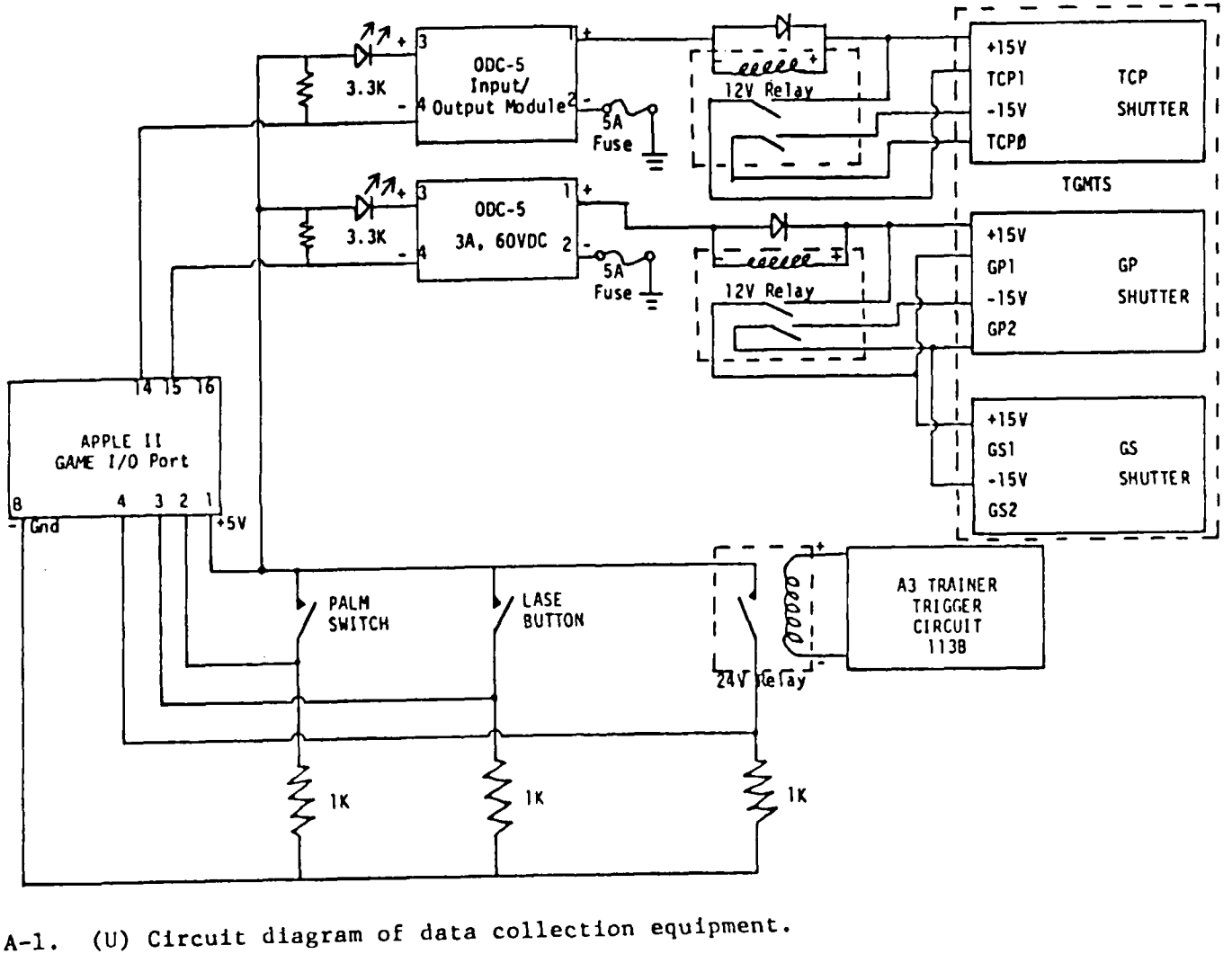

Figure A-1. (U) Circuit diagram of data collection equipment.

APPENDIX B
COMPUTER-BASED BIOGRAPHICAL QUESTIONNAIRE

TC Name Bumper Number

Gunner Name Bumper Number

Question	TC Response	Gunner Response
1. Ever trained together?		
2. How long assigned together?		
3. Time trained together?		
4. Wear glasses?		
5. Use glasses when firing?		
6. Time served in Armor?		
7. Ever used TGMTS?		
8. Number of TGMTS sessions?		
9. How long ago was TGMTS used?		
10. Time as M60A3 crewmen?		
11. Time as A3 TC?		
12. Time as A3 gunner?		

APPENDIX C
INSTRUCTIONS TO TGMTS OPERATORS AND SUBJECTS

TGMTS operator instructions

TGMTS Switching ON Procedures

1) Ensure that the Projector Mains is "OFF."

2) Turn the Console Mains "ON." (Allow 10 minute warm-up).

3) Turn the Laser "ON" with the Key switch.

4) Press the TEST button and ensure the laser can be seen.

5) Turn the Projector Mains "ON."

6) Load the film into the projector.

7) Ensure the Projector is set to REMOTE.

8) Set the Range switch on the Automatic Range Module (No 11) to the "X1" position.

9) Turn the Diminisher to "OFF."

10) Adjust the Volume and Tone controls on the Sound generator at appropriate levels.

11) Adjust the Volume Attenuator control (No 13) if further sound adjustments are needed.

TGMTS Switching OFF Procedures

1) Turn the Laser "OFF" and remove the key for safety.

2) Turn the Console Mains "OFF."

3) Turn the Projector "OFF."

TGMTS Operation

Prior to running subjects, the controls and switches on the Remote Control Unit must be set to their appropriate positions.

1) Set the AUTO-MANUAL switch to "Man."

2) Index the correct range for this engagement by using the "UP," "FAST," and "DOWN" pushbuttons.

3) Set the ASSESS-BURST control to "ASSESS."

4) Turn the timer knob for the ASSESS mode to 10 seconds.

5) Set the loading control to 10 seconds.

6) Set the Weapon Selector switch to number "3" (APDS).

7) Set the RETICLE PROJ switch to "OFF."

8) Set the switch on the trace panel to "TRACE OFF."

9) Set the IMPACT POINT PROJECTOR to "AUTO."

10) Ensure that the ERROR switch is "OFF.

When you are ready to run a subject, you should perform the following actions.

1) Load the appropriate film.

2) Enter the range to target for the scenario.

3) Verify film and range to target with the computer operator.

4) Place the RUN-STOP control in "STOP."

5) Place the FORWARD-REVERSE control to "FOW."

6) Switch the LAMP ON-LAMP OFF control to "ON."

7) Place the SIGHT selector switch in "GUN PRIM.

To run a subject:

1) Place the RUN-STOP control in "RUN" to start the film.

2) If the GNR says "Cannot Identify" and the TC say "From my Position," move the SIGHT selector switch to "T.C. PRIM."

3) When the crew fires the film will stop. If the crew does not fire by the time the scenario ends, put the RUN-STOP control in "STOP."

4) While the film is stopped, enter the RANGE for the next scenario.

5) If you stopped the film, move the RUN-STOP control to "RUN" when the crew and computer operator indicate that they are ready.

6) If the film stops because the crew fired a round, it will remain stopped for 10 seconds and then will automatically start with the next scenario. If you wish to stop the film longer than 10 seconds, you must put the RUN-STOP control in "STOP."

7) Do not allow the next scenario to begin until the gun tube is pointing toward the left-hand side of screen.

8) If a scenario must be repeated because of equipment failure or procedural error, the film can be backed up by placing the FORWARD-REVERSE control to "REV."

Instructions for the TGMTS Computer Console Operator

The computer operator will be stationed in front of the Apple II keyboard. He is responsible for controlling the Apple TGMTS computer program (ATGMTS). The computer program controls the opening and closing of the shutter devices on the TGMTS, and records times of key events in the simulation.

Hardware requirements: Apple II computer with 48K RAM, two disk drives, monitor, Mountain Computer Apple Clock in slot 4. The 16-pin DIP connector from the Apple/TGMTS interface board should be plugged into the Apple computer's game I/O port.

Software requirements: Three types of disks are required at the computer station.

1. The PROGRAM disk contains the ATGMTS computer program, a data file of conditions for each trial in the experiment, and some useful utility programs. The utility programs are not used during the TGMTS trial and will not be discussed here. The PROGRAM disk is always inserted in Disk Drive 1.

2. The SUBJECTS1 disk contains data for subjects 1 through 15 (or the first 15 subjects tested). This disk is always inserted in Drive 2.

3. The SUBJECTS2 disk contains data for subjects 16 through 27 (or the last 12 subjects tested). This disk is always inserted in Drive 2.

Whenever needed, the ATGMTS program will prompt you for the disk to insert in Drive 2. Moreover, it will not continue with the simulation until the correct disk (one of SUBJECTS1 or SUBJECTS2) is inserted.

Powering up the Apple II system: Make sure that the throw switch behind the computer is open. Insert the PROGRAM disk in Drive 1 and one of the subjects disks in Drive 2. Turn on the power switch on the computer. You should see a title page and a question as to whether you want to set the time. Press Y, since the battery on the Mountain Computer Apple Clock is not very reliable, and the time in the clock will probably not be correct. Follow instructions given for setting the clock. Close the throw switch.

Subject and Trial numbers: By default, the computer is programmed to do the subjects and trials in sequence. You will have to override this default is the sequence is broken, or if it is necessary to redo a trial. You should see the default subject and trial number for the next simulation:

NEXT TRIAL WILL BE FOR:

SUBJECT #: sn

TRIAL #: tn

The cursor will be flashing over the subject number. Press return if this number is correct. Otherwise, enter the correct number and then press RETURN. In either case, the cursor will move down to the trial number. Press RETURN if this number is correct. Otherwise, enter the correct number and press RETURN.

Rewriting tests data: Now the ATGMTS program will look up the data record assigned to the subject/trail pair. If this record is not empty then a message will appear:

WARNING: DATA ALREADY EXISTS FOR:

SUBJECT #: sn TRIAL #: tn

DO YOU WISH TO WRITE OVER IT (Y/N)?

This means that you are about to write over a subject/trial pair that has already been tested. Enter Y if this is what you intended to do (for example, if the previous data for this subject/trial pair is bad). The new data will be written to the data record, replacing the old data. If this is not what you intended to do (for example, if the subject/trial numbers are wrong), then enter N to escape the simulation and reenter the subject/trial numbers.

Identification data: If the trial number is 1, then the computer does not have identification data for the subject (names and bumper numbers). The program will prompt you to enter this data.

The simulation: The computer is now ready to begin the simulation. The conditions of the test are displayed. Check these for consistency with the test schedule. Read the range displayed out loud to the TGMTS Operator so that he can enter it into his device. The flashing cursor will appear after the prompt:

PRESS RETURN TO START

The computer simulation must be synchronized with the engagement film. Press RETURN at the moment when the banner on the film screen disappears and motion picture of the engagement scenario begins. As the engagement proceeds, lights will appear on the display indicating the occurrence of key events: shutters closing, palm switch release, lase, and fire. This is the "computer's view" of the simulation and can be used to monitor the system.

The computer operator must know how to recognize the fire command given by the tank commander. Press the space bar at the moment the tank commander begins to speak a fire command. Also, identify the tank designated by the tank commander. This information is needed later for scoring (see instructions for hit assessment below).

Ordinarily, the trigger will cause the simulation to end. Under certain circumstances, the crew will not be able to fire before the end of the film. The computer operator must then manually stop the simulation. Do this by pressing CTRL-S. In any case, a menu will appear on the display with the options: HIT, NEAR MISS, FAR MISS, and HIT WRONG TARGET. Study the projector screen and select the appropriate item (see instructions for hit assessment below).

All data collected and written to the data record will be displayed. Review the data and check for events out of sequence, identified by an "*." Any irregularities should be reported.

Press RETURN to continue on with the next simulation. This will take you back to the checking and entering of subject/trial numbers (see Subject and Trial numbers above).

Instructions for hit assessment: The computer operator will identify the tank that is the probable intended target. At the end of the simulation, a red dot will appear on the projector screen where the projectile hit. The following rules are used to score the hits:

1. HIT—The red dot is touching the tank.

2. NEAR MISS--The red dot is less than two "tank forms" away from the center of mass of the tank.

3. MISS—The red dot is more than two "tank forms" away from the center of mass of the tank.

Instructions to Subjects

During the next few hours you will be using your gunnery skills to engage targets on the Tank Gunnery and Missile Tracking System (the TGMTS). We will show you a total of four films that contain differing target arrays and ask you to engage these targets as you might on the battlefield. While engaging these targets, perform all of the activities that a TC and gunner would in an actual stationary engagement. This includes target acquisition and identification, fire commands, gunner's responses, and proper use of sights and rangefinding equipment.

Each film is broken into a number of engagements. The first film is for practice to familiarize you with the TGMTS and to allow you to work on your fire commands and engagement techniques. The other three films contain nine engagements each and your performance will be carefully scored on these. You should assume that you platoon is in a hull down defensive position. You are not the platoon leader or platoon sergeant. Assume that the following conditions are in effect for all engagements:

o Your TTS has failed, but all other systems are operational. All other systems including the 105D and the TC's sight may be used by the crew to acquire and hit targets.

o SABOT is loaded and indexed (APDS).

o First return is selected, because you are operating in desert terrain.

o The LRF is in the ON position.

o Precision gunnery techniques will be used throughout.

o Because we are using the TGMTS to simulate lasing, you may get four or more returns. If you do get four or more returns, you do <u>not</u> need to relase. Just select 1st return.

Now take your position inside the tank and check your switches and controls to ensure that they are set correctly. Notice that an additional switch is mounted on the TC's control handle. This switch will normally be engaged when the TC grasps the control handle. The TC should not release the control handle until the gunner announces "Identified." Otherwise an error will be recorded.

As you engage targets, I will be here in the loader's position observing your actions. Fire only once for each engagement, even if there are multiple targets. Don't reengage targets or fire at more than one target in each scene. When you fire, the film action will stop, and we will score hits and misses. After each engagement the gunner should turn the main gun switch off, return the main gun to the left hand edge of the screen, and get ready for the next engagement. The TC should make sure the gun is on the left of the screen, and inform the projector operator when the crew is ready, so he can restart the film.

The first film you see is for practice. You will fire once for every third engagement (nos 6, 9, 12, 15, 18). You may use the other engagements

to practice target acquisition or for adjusting your diopters. You may also ask questions during the practice, and I may comment on your actions. However, I will only be able to answer questions prior to and during the practice film. Do you have any questions before we start.

After the practice film you will see one of the other three films. After that film you will take a break while the other TC/gunner pair sees the first two films. We will then bring you back for two final films.

The TGMTS and your A3 trainer have been carefully boresighted, so you should not attempt to adjust the boresight knobs nor should you apply BOT. Any inaccuracy that you detect in the system is due to built-in dispersion in the TGMTS. This dispersion represents the dispersion that would normally occurr in firing live ammunition on the A3 tank.

You have completed the practice film. Do you have any questions?

Your performance will be scored on each of three remaining films. Remember to:

a. Fire only one round at each target scene using precision gunnery techniques.

b. Ensure that the LRF switch is in the "ON" position, and the first return is selected.

You will now engage targets on the last two films. Before you begin, you should:

a. Check to ensure that all switches and controls are set properly (e.g., Ammo switch on ADPS).

b. Readjust your diopters as needed.