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THE RELATIONSHIP BETWEEN THE MOVING TARGET RIFLE MARKSMANSHIP TRAINER AND THE MULTIPURPOSE ARCADE COMBAT SIMULATOR

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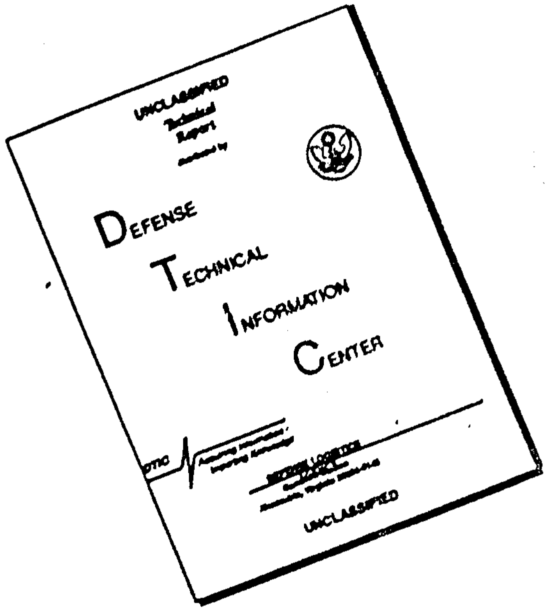

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In order to capitalize on cost reductions in microcomputers and avoid the increasing costs associated with live ammunition, the Army is currently investigating microcomputer-based simulators. Two such simulator/trainers are the Moving Target Rifle Marksmanship Trainer (MTRMT), and the Multipurpose Arcade Combat Simulator (MACS). The purpose of the present research was to determine the correlation between performance scores on these two simulators for both stationary and moving targets. The subjects were 28 volunteers who

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varied widely in their experience with firing a rifle. The resulting correlation coefficients between the two simulators ranged from r=.50 (MTRMT - stationary targets with MACS - stationary targets) to r=.74 (MTRMT - moving targets with MACS moving targets) and all of the resulting correlation coefficients were statistically significant. After outliers were removed, the correlations between the two simulators ranged from r=.34 (MTRMT - moving targets with MACS - stationary targets) to r=.55 (MTRMT - moving targets with MACS - moving targets) and 3 of the 4 coefficients were statistically significant. More research is planned to determine the correlation of both simulators with actual live fire. Keywords: M16A1 rifle.

THE RELATIONSHIP BETWEEN THE MOVING TARGET RIFLE MARKSMANSHIP TRAINER (MTRMT) AND THE MULTIPURPOSE ARCADE COMBAT SIMULATOR (MACS)

INTRODUCTION

Given the recent increase in the cost of live ammunition and decrease in the cost of microcomputers, the Army is becoming increasingly interested in weapon simulators. In addition to the potential cost savings, simulators may actually contribute to effective training in ways that are difficult to achieve in actual live fire. For example, immediate and precise feedback about hit or miss shot location are standard features in a simulator while often difficult to provide on a live-fire range. The purpose of the present study was to measure the relationship between two microcomputer-based marksmanship simulators.

One of the simulators was the Moving Target Rifle Marksmanship Trainer (MTRMT), a prototype marksmanship trainer developed by Spartanics Ltd., Rolling Meadows, Illinois. The MTRMT has three major components: the rifle, the target assembly, and the console (see Figure 1). The rifle is a simulated M16A1 standard service rifle. The weapon's adjustable recoil is produced by a metal rod that is attached to the barrel of the weapon. The sound of the report is also adjustable and delivered through headphones.

The target assembly can display any of a number of scaled silhouette targets representing a number of distances: 50 m, 100 m, 150 m, and 250 m. Each "E-type" target represents the head and torso of a man. The user can select targets which are stationary or moving. If moving targets are selected, then the user can further decide if the targets move left to right, right to left, or randomly. In addition, speeds of 1, 2, or 3 m/sec can be chosen.

The console contains the programming circuitry. On the front of the console are the various switches which allow the user to select from the large number of options available. In addition, a CRT monitor depicts the relevant target along with a white dot indicating point of aim. After a round is fired, the soldier can see exactly where his bullet would have hit. He can also replay his point of aim for the 1 sec prior to firing. In addition to the visual feedback, the user can also receive auditory feedback in the form of tone pitch (low tone=miss; high tone=hit) and a voice synthesizer indicating the location of misses (e.g., "high-left"). The MTRMT can also replay point of aim for moving targets. A printer is provided in the console so that hard copies of performance information can be obtained. For a more detailed description of the many features and options provided by the MTRMT, see Spartanics, Ltd., 1967, 1981 or Schendel and Williams, 1982.

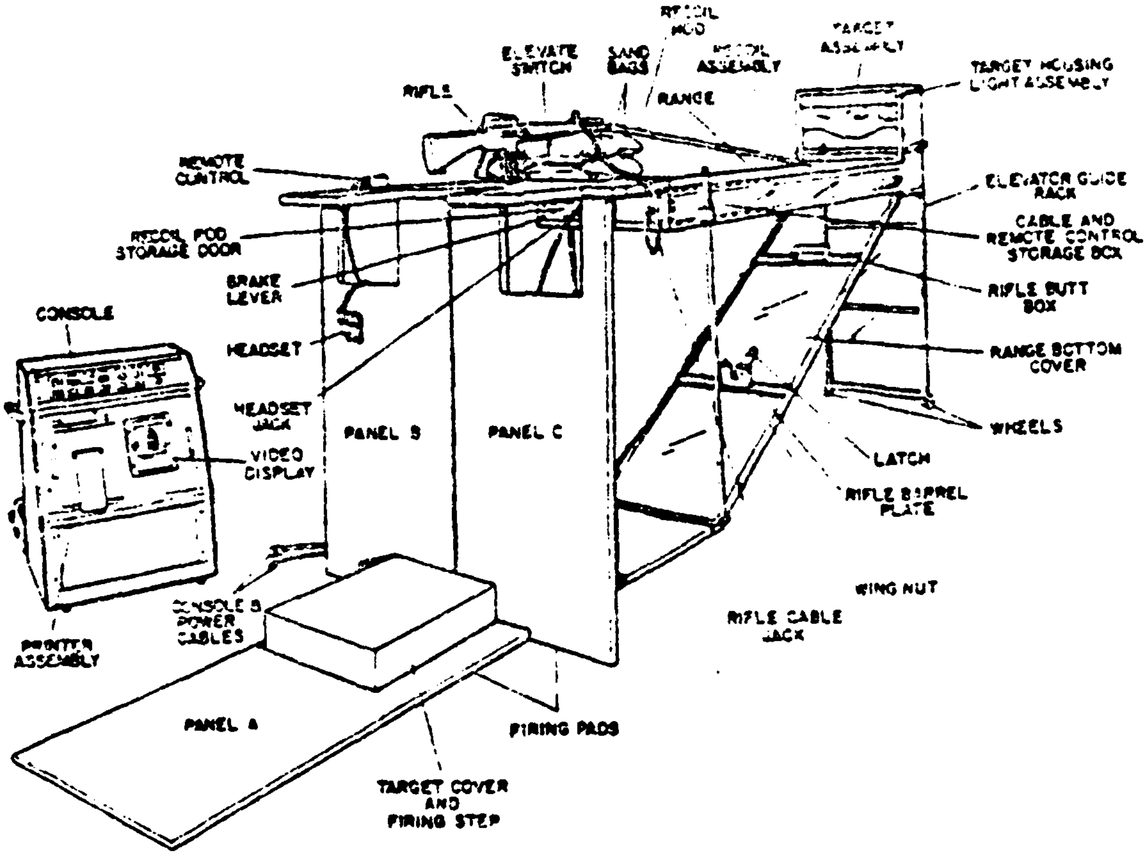

Figure 1. Figure 1 shows the hardware configuration for the MTRMT simulator/trainer for the M16A1 Rifle.

The second simulator/trainer was developed by the present author at the Army Research Institute, Fort Benning, GA. The name of the ARI system is MACS (Multipurpose Arcade Combat Simulator). While the MTRMT described above represents a very high fidelity and very realistic simulator, the MACS system represents a fairly low fidelity part-task simulator/trainer (e.g., there is no recoil or realistic sound built into the MACS system). The major potential advantage that the MACS system would hold over the MTRMT would be the cost involved: the components for the MACS system are much simpler and less costly and the MACS system has potentially more training applications since it is not dedicated to one weapon.

The MACS system is a relatively simple system composed of three components (see Figure 2). The heart of the system is the microcomputer and accompanying disk drives. Although many computers could potentially be used, the Apple II+ was used in the MACS prototype system. The second component is the monitor. Virtually any NTSC standard monitor should work with the system. The third component is the "dummy" weapon. MACS was created to be flexible so that many different weapons could be trained/simulated using the same core system. The only hardware elements that would change from weapon to weapon are the "dummy" weapons used and the computer software that controls the type of target (e.g., personnel, tank, etc.) or nature of presentation (e.g., stationary or moving target). The device that makes the MACS system possible and allows for flexibility is the light pen. The light pen used in the MACS system was specially adapted so that it could make accurate readings out to 5 m. The light pen was constructed so that it could be easily attached to and removed from different weapons.

In the MACS system, the user can select from several training options (e.g., stationary targets, moving targets with or without replay, effects of wind, etc.). Scaled targets are presented on the monitor representing different distances (virtually any reasonable distance can be displayed). When the user fires the weapon, the computer simulates a weapon firing. However, this sound is merely a cue that the weapon has fired and is not intended to simulate the sound intensity of actual live fire. The user receives both visual and auditory feedback. The visual feedback is in the form of a dot on the monitor that symbolizes where the bullet would have impacted. If the shot is relatively close to center of mass (within 5 pixels of exact center), the user also receives auditory feedback in the form of 1 to 4 "beeps" (the more beeps, the closer to center of mass). A numerical score is also calculated, presented, and a total score is accumulated. For motivational reasons, the MACS system was designed to resemble an arcade game as much as possible. For more detailed information about the MACS system, see Schroeder, 1983.

The purpose of the present study was to measure the relationship between the two simulators for both stationary and moving targets. Of course, the true test of any simulator is the magnitude of the correlation between performance on that simulator and actual performance on the task being simulated. Such studies have been conducted for the Weaponeer (the early stationary-target version of the MTRMT) yielding correlation coefficients of .41 to .66 reported by Schendel and Heller (1982) and .54 as reported by Schendel, Heller, Finley, and Hawley

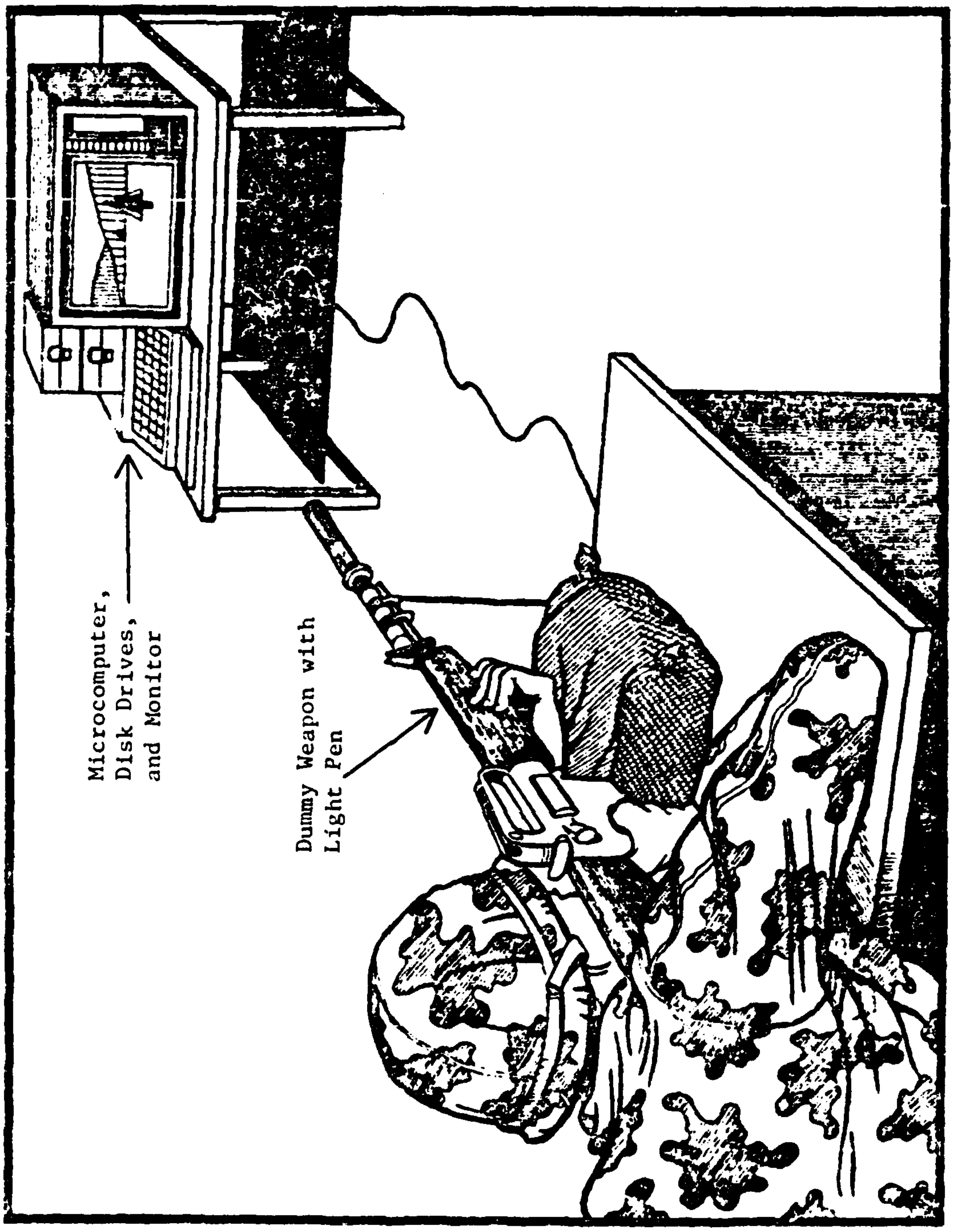

Figure 2. Figure 2 shows the hardware configuration for the MACS simulator/trainer for the M16A1 Rifle.

(1983). In the future, additional research is planned to determine the relationship of both of these simulators to live-fire performance and attempts will be made to isolate the variables that significantly influence those relationships.

Method

Subjects.

The 28 subjects were volunteers from the staff of the US Army Research Institute for the Social and Behavioral Sciences (ARI), volunteers from the staff of the Mellonics Systems Development Division, Litton Systems, Inc., and volunteers from the US Army Infantry Center at Fort Benning GA. Nine of the subjects were female and 19 were male. The marksmanship experience within the group ranged from novice (never had held a rifle) to expert (championship medalists).

Dependent Measures.

On the current MACS system, the computer calculates an error score by adding the absolute value of the "X" deviation (the difference in pixels between the X coordinate for the actual center of mass for the target and the X coordinate of the actual shot location) and the absolute value of the "Y" deviation (the difference in pixels between the Y coordinate for the actual center of mass for the target and the Y coordinate of the actual shot location), and subtracts that sum from 50. This calculation is made for each shot and the computer adds these scores to determine the final score.

On the MTRMT, no numerical score is provided (other than hit/miss data) so a numerical score representing radial error had to be created. In order to derive a measurement that would be somewhat comparable to the MACS measurement, a plastic template was constructed with 22 concentric circles (the radius of each circle was increased by 3.175 mm). This template was fastened over the CRT with the center of the circles positioned directly over the center of mass on the target. The center circle was given the value of "0", the first ring from the center circle was given the value "1", the second ring "2", etc. For each shot, the experimenter recorded the value of the ring in which the shot hit. Because the targets for the various distances are not all presented at true scale on the MTRMT, trigonometric corrections were made on these scores so that corrected scores would represent radial error for each range. Finally, the corrected scores were subtracted from 50 as in the MACS system. The manipulations described above were made in order that the scoring systems for the MACS and the MTRMT be analagous as possible.

Procedure.

Subjects were randomly assigned to one of two counterbalanced conditions: MTRMT followed by MACS and MACS followed by MTRMT. In either case, testing conditions were kept as similar as possible in an attempt to eliminate extraneous confoundings. On both simulators, stationary targets were presented first followed by moving targets. For stationary targets, subjects received the same scenario on both simulators with three shots allowed at each target. For both simulators, targets were presented in the following order: 100 m, 250 m, 50 m, 150 m, 250 m, 150 m, and 150 m. Subjects were allowed as much time as they wanted to take the three shots. For both simulators, when targets were presented at the same range, their lateral position in the display was changed. During the moving target test, targets on both simulators were scaled to represent 100m targets moving at 2m/sec. Direction of movement was alternated with targets first moving from left to right, then right to left, etc. A total of 8 targets were presented on each of the two simulators. All subjects were encouraged to utilize the feedback provided by both simulators. Following the data collection, all subjects were given a short debriefing and thanked for their participation.

Results and Discussion.

The results of the study are shown in Table 1. As shown, all correlations were significant. The lowest correlation was between the MACS - stationary targets and the MACS - moving targets in which 22% of the variance was explained. The two strongest correlations found were the MTRMT - moving targets with the MTRMT - stationary targets in which 56% of the variance was explained, and the MTRMT - moving targets with MACS - moving targets in which 55% of the variance was explained. Inspection of the raw data indicated that there were several "outliers" among the different variables which may have artificially inflated and/or deflated the correlations reported in Table 1. For the purpose of this paper an outlier was defined as any score that fell more than 2.33 standard deviations away from the mean for that variable. By chance, only 2% of the scores would be expected to fall beyond 2.33 standard deviations from the mean. In order to assess the effects of these outliers, any subjects with such deviant scores were omitted and another set of correlations was computed (see Table 2). Comparison of Table 1 and Table 2 indicates that the outliers in the present data did inflate most of the original correlations (the remaining sample size after the outliers were removed is shown in parentheses). All correlations decreased in magnitude except the MACS - stationary with Weaponeer - stationary correlation, which remained constant. All levels of significance dropped, partly because of smaller correlation coefficients and partly because of decreased degrees of freedom.

Table 1
Correlation Matrix for MTRMT and MACS
(N=28)

	MTRMT Stationary Targets	MACS Stationary Targets	MTRMT Moving Targets	MACS Moving Targets
MTRMT Stationary Targets	1.00	.50 **	.75 ***	.57 **
MACS Stationary Targets		1.00	.56 **	.47 *
MTRMT Moving Targets			1.00	.74 ***
MACS Moving Targets				1.00

* $p<.05$

** $p<.01$

*** $p<.001$

Table 2
Correlation Matrix for MTRMT and MACS
With Outliers Removed
(N's are indicated in parentheses)

	MTRMT Stationary Targets	MACS Stationary Targets	MTRMT Moving Targets	MACS Moving Targets
MTRMT Stationary Targets	1.00	.50 ** (N=26)	.60 ** (N=26)	.50 * (N=25)
MACS Stationary Targets		1.00	.34 (N=26)	.22 (N=26)
MTRMT Moving Targe			1.00	.55 ** (N=26)
MACS Moving Targets				1.00

* $p < .05$

** $p < .01$

In general, the MACS - stationary target measure had the lowest correlations with the other variables. One explanation is that the MACS - stationary target scenario was too easy and simply didn't allow enough variation in performance. Failure to allow one or both of the variables enough room to vary classically results in a low correlation coefficient. This explanation is supported by the fact that the scores on the MACS - stationary target measure were more highly negatively skewed, indicating the possible presence of a ceiling effect. The coefficients of skew for the four measures were: MACS - stationary = -1.77, MACS - moving = -1.11, MTRMT - stationary = -.52, and MTRMT - moving = -.22.

The correlations in Table 1 are relatively high for the general small-arms simulation arena. This is probably at least partly due to the fact that most correlations reported are based on the rather crude hit/miss measure. Using a microcomputer-based simulator allows radial error measures to be calculated and retained. Being a more precise measure, radial error has the effect of allowing the dependent variables to vary more. Hence, the chances of detecting a relationship are increased.

It is difficult to interpret the correlations in Tables 1 and 2 without some measure of the reliability of the separate devices (i.e., the extent to which each device correlates with itself). This information is not yet available for MACS and cannot be estimated from the present results because individual score data were not retained in the present version of MACS. However, individual shot data were recorded for the MTRMT. Reliability estimates were determined for the 150-m stationary target, the 250-m stationary target, and the 75-m moving target. The 150-m target was presented a total of nine times. To obtain an estimate of the reliability for the 150-m target, the sum of the scores for the first, third, seventh, and ninth presentations was correlated with the sum of the scores for the second, fourth, sixth, and eighth presentations. The score for the fifth presentation was not used in order to allow an equal sample size for both sets. The reason for using counterbalanced grouping was to reduce any possible systematic effects due to learning, fatigue, etc. The resulting correlation for the 150-m target was $r=.36$, $p>.05$. However, when outliers were removed using the method described above, the correlation increased to $r=.56$, $p<.01$. The 250-m target was presented six times. The scores for these six shots were divided into two subsets: the first, third, and sixth scores formed set one and the second, fourth and fifth scores formed the second set for odd-numbered subjects; and the first, fourth, and sixth scores formed one set and the second, third, and fifth scores formed the second set for the even-numbered subjects. The resulting correlation was $r=.75$, $p<.001$ for the 250-m target. Removing outliers using the method described above slightly lowered the correlation to $r=.72$, $p<.001$. To obtain an index of reliability for the 75-m moving target scenario, the first, third, sixth, and eighth shots were combined to form one set and the second, fourth, fifth, and seventh shots were combined to form the second set. The resulting correlation was $r=.50$, $p<.01$.

Removal of the outliers resulted in a nonsignificant correlation of $r=.35$, $p>.05$. Although these correlations are based on a small number of shots, they should provide a rough estimate of the reliability inherent in the MTRMT. The correlations found between Weaponeer and MACS in Tables 1 and 2 are based on more scores and hence are more stable and not directly comparable with the within-Weaponeer reliability. Nevertheless, the correlations between the two simulators do seem to approach the within-simulator reliability of one of the simulators.

The significant positive correlations found in the present study are encouraging. It appears that the two simulators are measuring something in common. However, more research is needed to determine the extent that both these simulators are correlated with actual live fire.

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